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MACHINERY:

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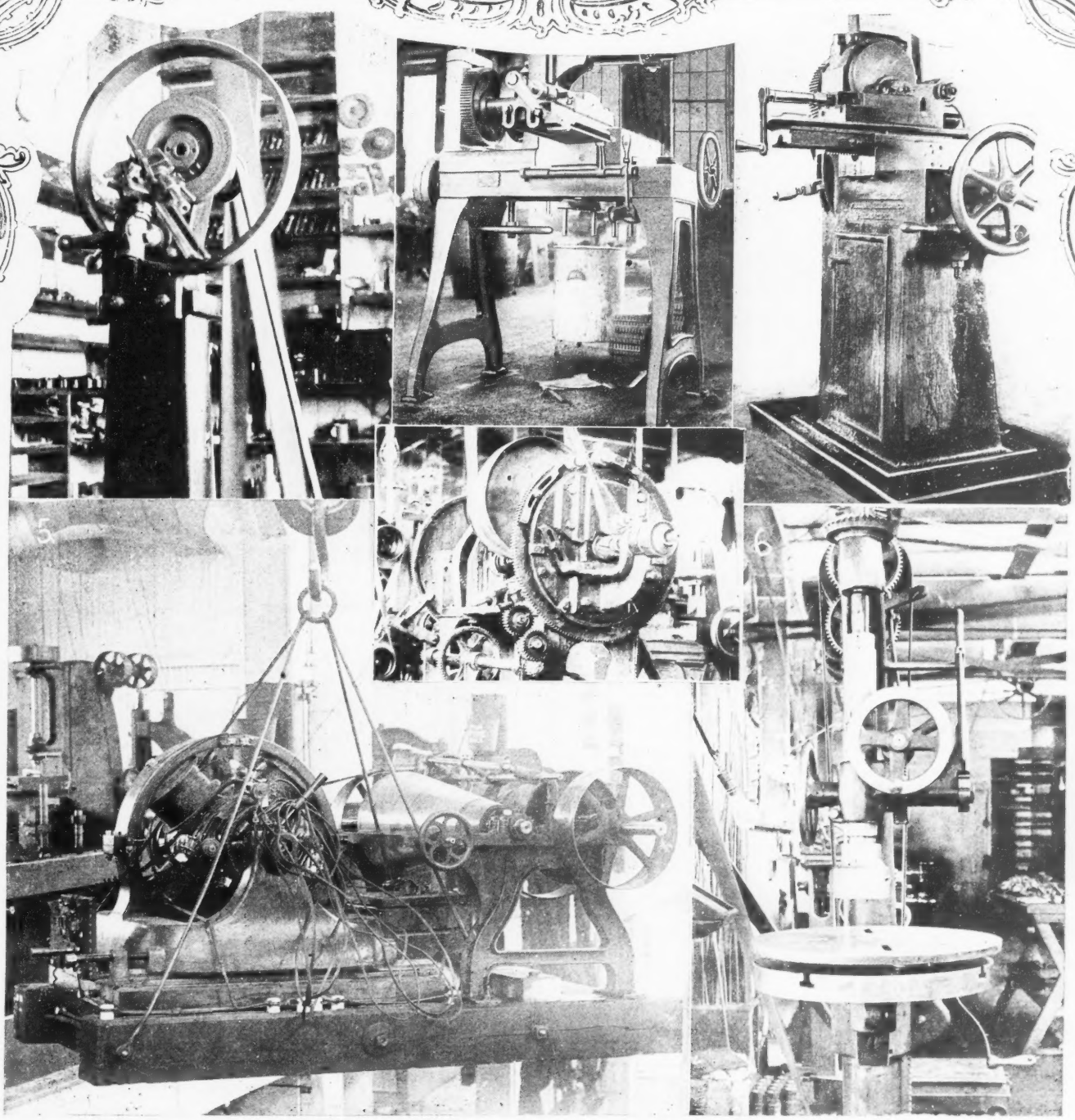
A PRACTICAL JOURNAL FOR MACHINISTS AND ENGINEERS AND FOR ALL WHO ARE INTERESTED IN MACHINERY:



1.—EMERY WHEEL GUARD (NORTON).
2.—OLD COLT MILLING MACHINE.
3.—OLD SELLERS MILLING MACHINE.

A GROUP OF APRIL ILLUSTRATIONS.

4.—OLD PACKARD MILLING MACHINE.
5.—MOTOR FOR TESTING MACHINE TOOLS.
6.—FALSE TABLE ON TABLE CHUCK.

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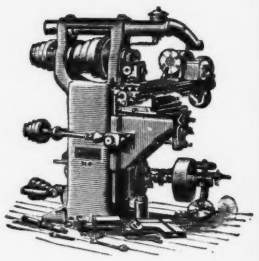

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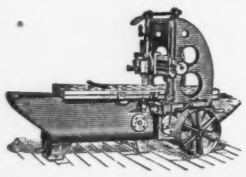

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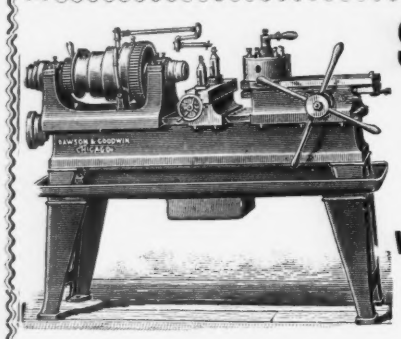

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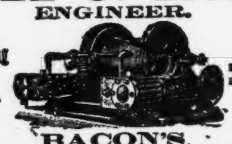

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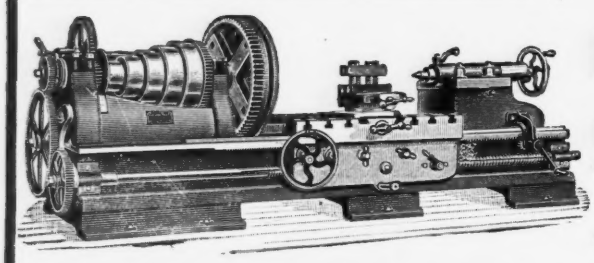

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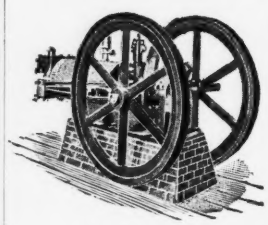

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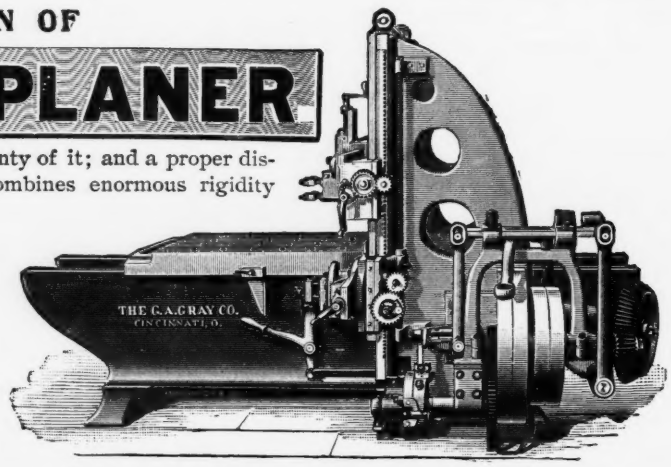

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MACHINERY.

VOL. 2. April, 1896. No. 8.

SOME EARLY MILLING MACHINES.

WHILE we do not believe in admiring antiquities simply on account of their age, yet when we find ideas of design and construction which are considered modern, embodied in tools of fifty years ago, it seems but right to give the credit due the older machine the same prominence we do in the case of a new machine. It is also interesting to trace the development of machines as well as possible and note the changes made from time to time.

Although not the originator of the milling machine in this country, Mr. Frederick W. Howe, whose portrait appears below, was one of the pioneers in the development of this machine and deserves considerable credit in this direction, having left his mark on many of the designs of today, and having a hand in the growth of the world-wide famed Brown & Sharpe milling machine.

F. W. Howe

That he was not the originator is shown by the little milling machine in the lower left hand corner of the group on page 229, which was discovered in the shop of The Silver & Gay Co., North Chelmsford, Mass., where Mr. Howe learned his trade, and the photograph was secured by Miss Gay, who kindly made the negative for us.

This is rather a peculiar machine in some ways, but aside from its lightness, the variety of movement and the attachments shown made it quite a desirable machine in many ways.

The exact date of this machine could not be obtained, but the record showed sales as early as March, 1841, to the Amoskeag Land and Water Power Co., which was followed by sales to such concerns as the Lowell Mfg. Co., in January, 1843, the Stark Mills, of Manchester, N. H., in 1844, and many others, it being sold under the various names of "whirl cutting," "butt cutting" and "milling machine."

The milling spindle is driven by the gears shown, which would hardly be suitable for mill surfacing work, but the cutter being supported at the outer end is an advantage over the old Pond machine, which the moving head somewhat resembles. The slack of belt is taken up by the idler and the right, and this vertical movement of the head vividly recalls the days when the writer steered an old Pond machine with this same feature through a great variety of work. Once in a while the machine steered me, for the milling cutter was not supported, but overhung about six inches, and would crawl into the work in spite of all one could do.

Lateral motion was secured by the cross slide shown, which carried the vise which is in place, or the index cutters shown standing against the base. The slide shown below is for milling the sides of nuts or similar work, when held in a vertical position, or for cutting slots across the top or face of a blank of any kind at regular intervals. It replaces the slide carrying the vise, and is operated by the same screw. The long handle evidently controls the opening and closing of chuck while the index pin is shown at the left below the handle. Whether this is the oldest milling machine or not the writer does not pretend to say—but it is the oldest I have found. While it is quite likely that the firs actual milling was done by the early clock makers of the Naugatuck Valley, as suggested by Horace L. Arnold, it is hardly fair to class their work as machine shop milling, and in this line the machine shown is probably the first, at least of those that can be found in existence or in use to-day.

Of the planer type, or, as it has come to be called on account of the push made in this direction, the Ingersoll type, the one in the upper left hand corner of the same group on page 229, can also be justly called a pioneer, dating about with the other machine. These were called slabbing machines. This has a wooden base as shown, the bed moving on iron ways placed on the wooden base. The whole saddle of the machine, including driving pulley and gears, raises and lowers on the posts by screws and bevel gears shown.

Probably the next type of machine was the Lincoln miller, introduced by the Phœnix Iron Works, of Hartford, Ct. This type of machine was also made by the Robbins & Lawrence Co., of Windsor, Vt., under Mr. Howe's supervision, and one of these machines is shown in the same group on page 229. This is still in use in the Billings & Spencer Co's. shop, and has one feature which might be looked into more carefully at present, namely, a wide feed belt which can carry about any cut desired. The general features are very similar to later machines of this class with the exceptions of the method of transmitting feed to carriage.

Other machines in this line were found in the United States Armory, at Springfield, which are shown on page 230, in Figs. 2 and 3, and which the records, kindly obtained for me by Col. Mordecai, the commanding officer, showed to have been made in the Armory in 1863, although the fact of their being finished and polished all over, except the legs and bed, would indicate that it was Armory work. One has an overhanging arm, the other is plain, the main feature being the long pinion for insuring the meshing with gears at different lateral positions.

The earliest machine of the well-known "Knee" type which I have found is also shown in the group, in the lower left hand corner. It is in the works of the Pettee Machine Co., at Newton, Upper Falls, Mass., and was built by Smith & Coventry, of Manchester, England, in about 1860. Mr. Mills, the superintendent, also informed me that similar machines were built by Collyer, also of Manchester, about the same date. This has the overhanging arm, bolted on to the frame, and the general appearance is not unlike later machines, except that it is gear driven. Fairly heavy work is done on machine, as shown by the good sized mill on the arbor. Another machine found here was the vertical milling or drilling machine, in the upper right hand corner, which was also of comparatively ancient date.

Another form of the Lincoln miller is shown in the lower center picture, built by Wm. Mason, the then well-known locomotive builder, of Taunton, Mass. This is also in the Billings & Spencer Co's. shop and doing good work to-day.

I am informed by Mr. Lucien Sharpe that their first machines were of the Knee type, and that the first one was sold to the Providence Tool Co., March 14th, 1862, but is now in Brown & Sharpe's possession.

Another form of machine which was adapted to a slabbing or planer type by Mr. Mills, is shown in Fig. 4, which is used for milling groups of small work as shown by pieces on the floor. This has chain feed.

The head moves vertically for different heights of work, and the detail in Fig. 5 shows how the gear is kept in mesh with the driving pinion which does not move with it. It will be seen that the driving cone is in a swinging frame, so that as the gear is moved the pinion can be swung.

In Fig. 6 is shown one of the earlier types of the Sellers' milling machines. This is on the plain miller order, and the varied heights of milling cutter is obtained in a rather peculiar manner, by rotating the large bushing shown in the head which carries the spindle in an eccentric position. The cut shows the milling cutter in about its lowest position. These are very compact machines but are not seen very frequently.

In the adjoining cut, Fig. 7, is another odd machine, built by Mr. Packard for making his ratchet wrench handle, and was bought by the Billings & Spencer Co. when they started making this well-known wrench. It is a double ended machine, each end handling a wrench handle as shown by the end in view. The handle to be milled is mounted on the arbor shown just above the milling cutter, and the slide carrying said arbor is forced down to the required depth of cut, and the outer geared ring then carries it around as far as desired, being stopped automatically at the right point. The handle is driven by the studs shown on the outer disk, or rather driven by one and steadied by the other.

In Fig. 8 we have a machine not unlike the ones in the Springfield Armory, being a product of the Colt's Armory in earlier days. This has a rack feed which is tripped by a latch, somewhat similar to the later machines.

The remaining machine, Fig. 9, is also the product of the Phœnix Iron Works, and is quite a novelty in many ways, having enough movements to be classed as a universal machine and is a very handy machine to operate. The table carrying vise can be raised, lowered, or swung round for circular work. The index plate is placed horizontally beneath the machine and is of good size, while the traverse motion of the head is controlled by the long lever to the right. Altogether they form an interesting collection of the earlier forms of this useful machine.

* * *

HANDY TOOLS FOR PATTERN MAKERS.

PANEL GAGE—DOWEL PIN CUTTER.

PHIL. PASTRE.

Pattern-makers generally like a long stiff panel gage, and I am one of them. I have been working a good many years with the old-fashioned one; I have tried the V-shaped one, but even then the stem would spring; so last December I made one as in Fig. 1. It is a common 20-inch gage, with a small head A, braced to the larger head C by two small pieces of brass B, ⅛ inch thick, ½ inch wide and 6 inches long, with a hole in each end for ½-inch screws, and when put together properly makes a good stiff panel gage.

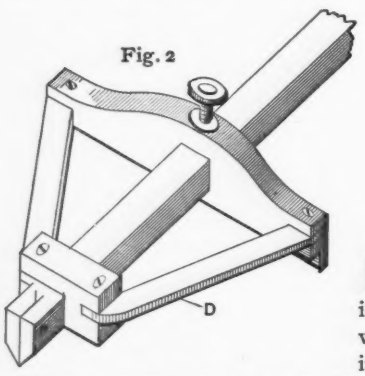


Fig. 2

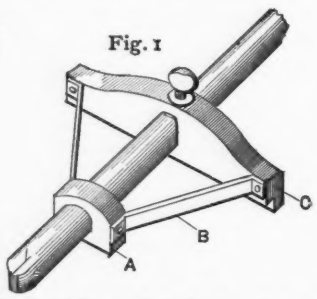


Fig. 1

Then I made a 30-inch gage as in Fig. 2. This gage is similar to Fig. 1, except that all the parts are made of cherry. The braces are $\frac{3}{16}$ inch thick, ⅝ inch wide and 8 inches long; they are set in flat, and being of wood are much stiffer than if they were on edge. This makes the best gage I have ever seen, and any one can easily change their old one.

The pattern-maker, as a rule, is not "stuck" on making dowel pins, especially if they only need 5 or 6 inches. He will probably spend ten or fifteen minutes hunting a piece, or wait about the same length of time until his neighbor has his back turned, and then "swipe" a piece from him. In the shop where I work there is no need of a pattern-maker losing time on dowel-pins; that is if the apprentice boy tends to his business.

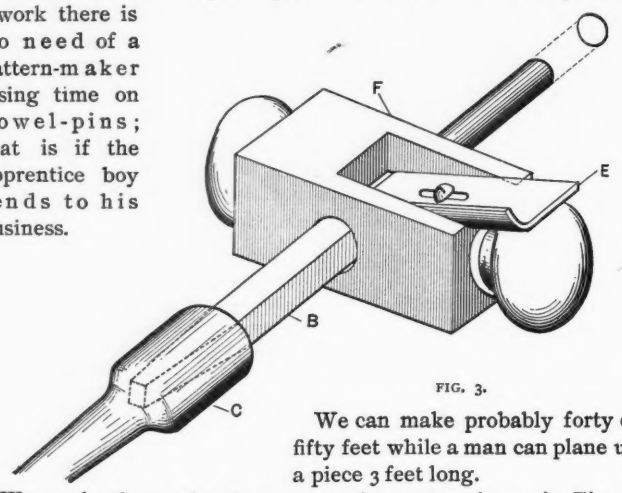


FIG. 3.

We can make probably forty or fifty feet while a man can plane up a piece 3 feet long.

We make these pins by means of a cutter shown in Fig. 1. They are all made in the lathe, running at its highest speed. We have a cast-iron chuck C with a square tapered hole, that will take in from ¼ inch up to 1 inch square pin stock.

Fig. 3 shows the cutter about half way down on the pin B. The knife E is something similar to a plane bit; the only difference is the bend or curve on one side. The main body F is made of hard wood with a knob on each end to hold it by. Fig. 4 gives the dimensions of the ½-inch cutter; the other cutters are made proportionately large or smaller. The larger end of the hole *b* is where the pin enters, prior to being cut. The hole at *a* should be a little larger than your ½-inch fit, so as to drive tightly. In making each cutter separate, you don't have to bother changing or setting your bits. Try one of these cutters (any size), and you will never be without them.

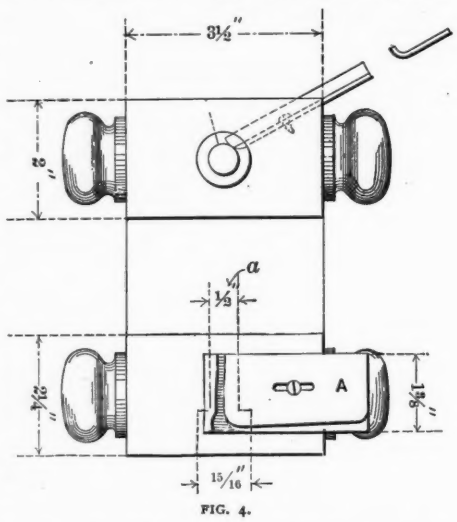


FIG. 4.

We have been using three cutters in our shop for at least two years, and it is a rare thing to see a man making his own pins.

* * *

CASTING NAMES ON BEDS AND FRAMES.

W. L. CHENEY.

Nothing looks worse, in my opinion, than a machine with the maker's name cast on it in a slouchy manner, and nothing is easier to achieve when, as is so often the case, the name is put on the pattern with ordinary pattern letters. These pattern letters have no individuality—they all look alike; and even if they were artistic in themselves, it would still be an easy matter to make a bad job of casting them.

A little kink on this matter will make it easy to have a neat name-plate cast on every machine: *First*, get a nicely designed and engraved plate. Plain gothic letters are in my opinion the most appropriate for a machine, and incidentally they are the hardest to design and engrave well. *Second*, get an electrotype of the plate (sand will wear the original out too fast, if much used), and use this electrotype as the bottom of a core-box. *Third*, put a core print on the pattern where you want the name to appear. The result is self-evident, and the scheme needs no further explanation.

* * *

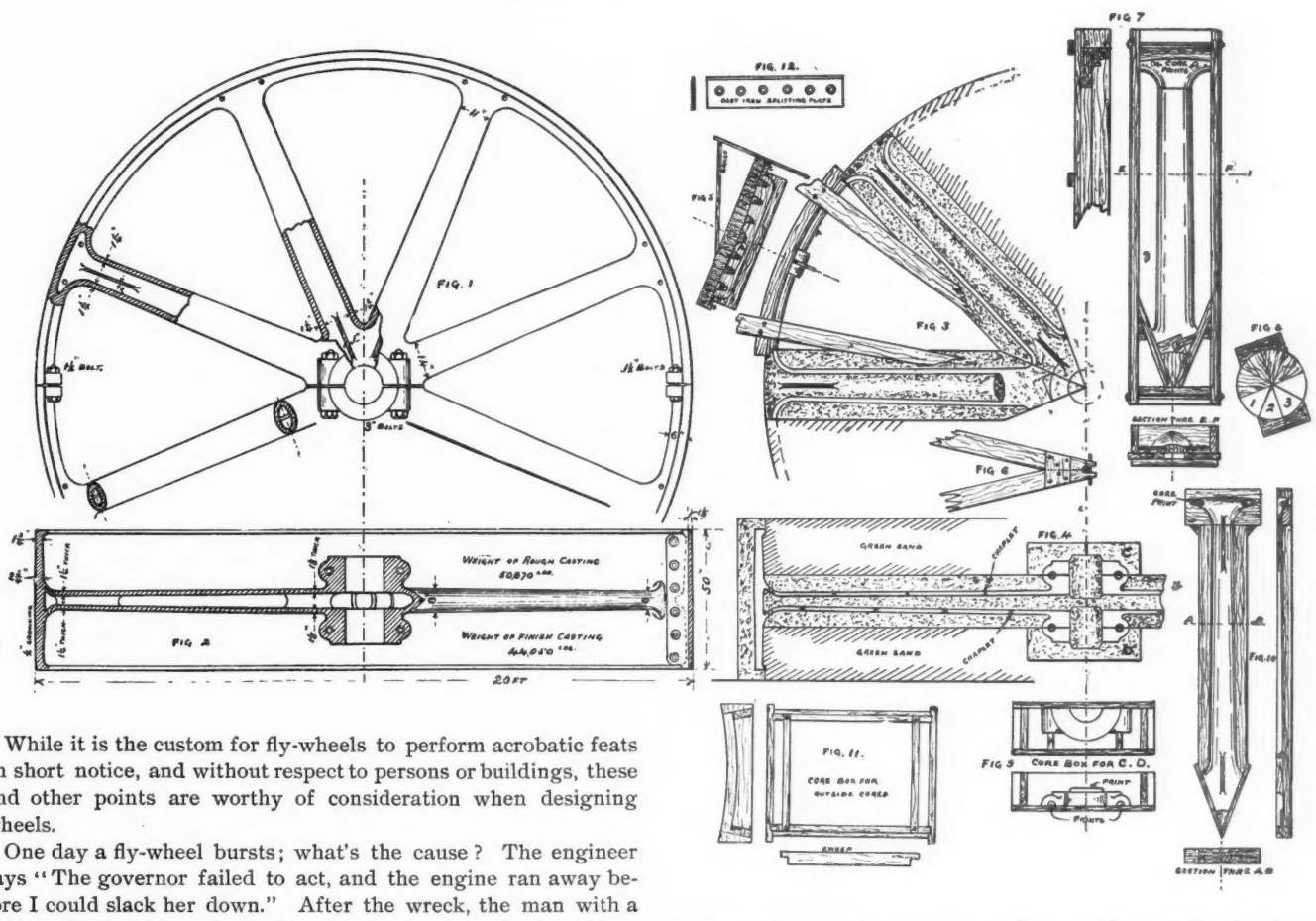
Want of care does more damage than want of knowledge.

PATTERN MAKING.

MAKING HOLLOW-ARM FLY-WHEELS.

P. S. DINGEY.

It is a question whether many wheels, the rims of which are made in sections of eight and twelve pieces, with arms and hubs separate, would not be as safe, and perhaps safer, if made in halves—certainly cheaper, though where danger to life is involved, cost should not be considered at the expense of the proper construction of fly-wheels. The former method, however, possesses certain advantages which the latter does not, and *vice versa*. For instance, a wheel made in sections is more easily handled in shipping and is not subject to the torsional strain due to shrinkage, that one made in halves may be; but over against this there is the loosening of bolts and joints, that frequently happens to a fly-wheel built in sections, whereas with one that is made in halves this danger is diminished, and also when turned and in place will generally run true and in balance, when the one built in sections will not.



While it is the custom for fly-wheels to perform acrobatic feats on short notice, and without respect to persons or buildings, these and other points are worthy of consideration when designing wheels.

One day a fly-wheel bursts; what's the cause? The engineer says "The governor failed to act, and the engine ran away before I could slack her down." After the wreck, the man with a bulging forehead knowingly inspects the grain and color of iron in broken parts and pronounces the quality to be inferior; another declares the bolts were too small. Any or all of these verdicts may be right, for a runaway engine with a large fly-wheel soon decides the difference between the strength of the wheel and the centrifugal force.

Two years and a half ago I was required to design and get the necessary core boxes, etc., made for a 20-foot by 50-inch face fly-wheel, to weigh about 22 tons. The question of making it in halves or in eight segments, with arms and hub bolted together, was discussed. It was decided to cast it in halves, with the arms cored out as shown in Figs. 1 and 2. To get the arms of a fly-wheel strong enough to withstand the shrinkage of casting while cooling is a point not always considered. The cross-section at the small part of the arm may be faithfully computed, yet it is generally understood the cracking of fly-wheels which sometimes occurs in the foundry while cooling is due to insufficient metal in arms compared to other parts. The molder often prevents this by uncovering heavy parts of casting, especially the hub, thus allowing it to cool simultaneously all over, or as near to it as possible; the shrinkage strain, however, may be so great, owing to bad proportioning, that with all the precaution a molder takes, it does not prevent the wheel from breaking; hence the necessity of considering shrinkage strain and adding a large factor of safety to arms.

This article being intended more for pattern-makers than others, the foregoing may appear irrelevant; it is desirable for a pattern-maker, however, to know the way a casting will act under certain conditions, so that when given a drawing of an ill-proportioned piece of machinery, he may be able to suggest to the draftsman what is likely to happen to the casting in cooling.

I have given a few of the principal dimensions, in Figs. 1 and 2, of the wheel mentioned, which was successfully cast in halves, with hollow arms.

From Figs. 3 and 4 it will be seen that the inside of mold between the arms of fly-wheel, is rammed up in green sand by means of a segment pattern, a section of which and the lug for bolting wheel together, are shown in Fig. 5. Where the two arms which are fastened to this segment join, a place is cut out to fit around the spindle shown in Fig. 6. The braces to keep the lower part of sweep from being rammed out, are put on the outside, so as not to interfere with the molder when ramming. The inside rib A is not built up with the segment pattern, but is made separate and screwed on after working off the inside of segment, this being a much easier way than building the head into the pattern. The two outer ribs B and C are also made separate and screwed on. The segment pattern is wider on the face than casting is required to be; the object of this will be seen by referring to the cores forming the outside of mold in Fig. 4. This plan for forming the outside is not perhaps the best, but it was found to be the most convenient. Of course a much better job could be done by building up the outside with brick on a cast ring, and sweeping it in loam, but I am giving the manner in which this wheel was made, and not the way it might be. The whole mold was enclosed in a ring made from old boiler-plates, and sand rammed between the cores and ring.

The core-box for the outside of arms is shown in Fig. 7, and is fitted with interchangeable pieces in the end, for making the hub to centers of bolt-holes; the parts numbered 1, 2, 3, Fig. 8, are the only pieces needed. The cores C and D in Fig. 4, made from box, of which two views are shown in Fig. 9, complete the hub. Joining the hub cores in this manner allows the cores for the bolt-holes (which are chambered) to be easily set.

Fig. 10 is the box for making the inside arm-cores, and Fig. 11 the box from which to make cores for outside of wheel. The construction of these boxes will be easily understood from the differ-

ent views given. There are two 2-inch prints in the outer end of each arm box, for the purpose of setting 2-inch round cores for carrying the outer ends of inside arm-cores; the inner ends rest on the center core, while chaplets are used to support the cores between (see Fig. 4). All the "vent" from the cores was taken off through the center.

On each side of the lugs on rim in Fig. 5 are shown six prints for carrying bolt-hole cores. The cast-iron plate in Fig. 12 is for cutting the rim and is made to fit the flat print on lug. To locate the bolt cores and plate, the cores are put through the holes in the plate and the whole set in place together, putting them in from the outside and building over the six cores. The holes in the plate are cut about an inch larger than cores, in order to form a bearing around the holes, thus preventing the lugs from springing when screwing up bolts. Cast iron plates are also used for splitting the hub, but no bearing surface should be allowed between the split, as it might interfere with the shrinkage of arms.

* * *

LABOR'S VALUE.—(1).

W. S. Rogers.

One of the vexing problems in all manufacturing establishments is the fixing of a true valuation on the cost of labor, and the question with all its painful carbuncles of strikes and lockouts on one side and the embarassments from not being able to meet commercial competition on the other, will never find a peaceful settlement until we all realize that every man has a divine right to live and enjoy the fruits of his labor, to the full extent that knowledge of his business, aided by his physical powers, gives him the ability to earn.

Estimating the cost of materials is an easy matter, because all the component parts have a market value based on commercial prices, which change only as the price of gold, iron, or raw materials fluctuate. The fixed charges and taxes are easily obtainable and percentages nicely divided and spread over the year's production, but the labor value to obtain that production is never a satisfactory figure with either employer or employed, because it is seldom accurately known. The ambitious, hustling workman is dissatisfied because the slower one rates as high as himself; the noisy agitator is sowing seed of distrust because the foreman doesn't think he is the best man in the plant; the management is constantly hammering the superintendent to reduce the cost; he in turn crowds the foremen, who in turn become drivers among the workmen without any sense of the eternal fitness of things, and the whole mass becomes impregnated with feelings of revulsion and hatred, explained in one simple word—anarchy.

In olden time, work was done by the day, but in the present day, when men's mental and physical natures differ so, the term "day's work" means nothing except that the man came in the morning, remained through the sunny mid-day hours and left off at night. No inducement is offered for one man to excel more than another.

Now we have "piece work," "contracts," "profit sharing," "gain sharing," "premium plans," and "differential piece rates," each scheme having its own believers and followers crying down those opposed to them, but when driven to the wall in argument it usually transpires that they know practically nothing of any method excepting their own pet hobby and "day work;" consequently every other plan is wrong and a sign of lunacy, and their invention the only true way to salvation.

Always having been a sort of philosopher and never having ability to invent a system I could call *mine*, I have been able to carefully study and experiment with all "cure-alls" invented by the doctors in a cold-blooded, practical way during the past fifteen years in which I have been in charge of factories without detriment to the firms, profits, or being advised to look elsewhere for a situation. In my work of investigating the methods used in different plants, I have been careful to get the opinions of not only those in charge of the works, but the ideas of the workers as well, and seldom have I found all parties in a state of harmony.

If *all* men were constituted alike; if *all* superintendents and foremen were honest to the workmen and employers alike, then the honest, easy way to employ labor would be by the day. But such is not the case, and conditions must always govern results. The most common remedy for reducing cost of production and putting a fixed labor value on finished work is "piece work," but it does not make truthful foremen by any means, and it does degrade excellence of workmanship; and when a firm obtains a reputation for doing poor quality of work, it is but a short time until sales begin to dwindle away.

My first attempt was with plain, old-fashioned piece-work. It was in a shop in Ohio. An engine had been sent to our shop for repairs, and the proprietor and myself had looked it over carefully and agreed that it would cost just about fifty dollars in actual wages to do the work. He was a practical mechanic also, and wanted to try piece-work. I put Jerry Rusk, a three dollar per day man, on the job for forty-five dollars, and in just sixty hours Jerry had earned his cash, the proprietor was crazy and I was astounded. I thought I knew Jerry's ability as a worker, but I discovered my mistake. It was three weeks before I gained consent from the firm to try it again; and after I had fixed a price the office shaved it 20 per cent. This time a slower man was on the work; he did not make his usual wages, and to keep him the price had to be raised.

My next work was in a carriage factory. Girls running Elliott sewing machines were earning six dollars a week. I was to put them on piece-work so the firm could get out more orders. At the end of three weeks their pay per week amounted to ten dollars; in four weeks it was eleven, and at the end of two months they were earning twelve dollars per week, and then judgment day came. The manager sent for me to come to the office. He said: "Young man, I see those women in the machine room are making twelve dollars a week; you must cut their prices." "But, I answered, "they are turning out two and one-half times more work than under the old weekly rate plan." He replied: "I can't help that; I don't like the idea of a woman earning such amounts and won't have it." We cut the price 30 per cent. The girls struck, we lost three weeks, broke in a new set of hands, and did not fill several orders because our manager didn't use the same politics in business that he did in the city council. An official high in control of the employees of a leading electrical company recently told me "it was against his principles to allow a woman to earn more than a dollar and a quarter per day, no matter if it did rob his company." Was a broader acknowledgment of dishonesty and cowardice toward the opposite sex ever made? In the winding department of this company men are allowed to make two dollars and two fifty per day, but the nimble-fingered women on the same work does not exceed one twenty-five, or she gets a cut in her rate. And still some people are foolish enough to call "Man the noblest work of God."

A three months' investigation of the methods in vogue in the Electric Works convinced me thoroughly that piece-work or contract methods only tend to elevate ignorant foremen in the eyes of their superiors, and to give the dishonest ones opportunities for throwing fat plums into the hands of favorite workmen. Here is an actual working contract ticket:

> Ticket No. 113,509—Winding and connecting 800 K. W. D. C. Eng. Type Armature.—Began Dec. 11; finished Dec. 16; by Charles Sparks, rated at 24 cents per hour, and assisted by workmen Nos. 757 (22 cents), 764 (25 cents), 751 (20 cents), 752 (22½ cents), 753 (16 cents), 754 (22½ cents), and 758 (16 cents).

No contract price was put on this ticket until the job was completed, and then the foreman figured Mr. Sparks' time at 40 cents per hour, and the time of the others at 30 cents per hour, making a total of $53.20.

> Ticket No. 120,557. Shop Order 7,381. Winding and Connecting Armature.—14¾ hours by one workman rated at 33 cents per hour and another workman rated at 24 cents per hour, also putting 14¾ hours on the job. In this case the 33 cents' man's time was multipied by 45 cents and the 24 cents' man's time by 36 cents, after completion.

In these cases no inducement was held out to the workmen to save any time, as they knew by experience that the foreman would "fix" the time so they would not lose by the operation. Another feature of the dishonesty of such piece-work or contract methods outside of robbing the stockholders was the injustice practiced on the low-rated man. He knew just as much about the work and worked just as hard and faithfully as the 33 cent man; then why were not his hours of labor multiplied by 45 cents as well as the others? First, he was not as great a favorite as the other man; did not come from the same place on the map. Second, it was known throughout the shop that so long as the earnings of the men on piece-work did not exceed one and one-half their hourly rate, no orders would come from the superintendent's office to cut the future prices for this work. And I

must contend that the workmen were fully justified in holding up prices. It is a commercial transaction in which the men with the most brains win.

Another method of setting prices on contract work is this: The general foreman sets a price of $75.00 on an armature building job. After two days' work on it he takes the ticket from the workman and changes it to $70.00, and three days later he again alters the ticket to $65.00, giving me as a reason "that he did not propose to allow any workman to rob the company." Truthfully, he was only shielding his own ignorance of his business, setting an example to his subordinates to cheat, and creating the impression among the workmen that the capitalist approved of such methods of breaking contracts.

Another method is to make out the piece-work ticket and fix the price before giving it to the workman, and then as the work progresses and the foreman discovers that the man will not make any profit on the job, to shift his time on day work rates, probably on another shop order, something after this plan:

Card 3,822. S. O. 311. June 19, 1896. Henry Eberhard, workman. One Piece. Kind of Work, Turn and bore fly-wheel. Price, $6.00

TIME.

June 19.....	5 hours	June 22.....	8 hours
" 20.....	10 "		—
" 21.....	10 "	Total.....	33 "

NOTE.—Deduct 13 hours from this and charge to day work.

J. BURTON, Foreman.

In this case the man was a loser according to the contract. It would not do for the office to know that the foreman did not know his business, so the notation to the paymaster on the ticket makes it all right with the workman, and the $6.00 price on the stub is smooth enough when the superintendent sees it.

The all important item in bringing about cheap production lies wholly in the quickness with which the work can be done, and any manager, superintendent or foreman who puts any hindrance whatever in the way of lowering the time on a piece of work from ten hours down to one hour if it is possible, is simply robbing his employes and is in the business the same as a politician is in politics—for what there is in it. This is rather drastic, but it is true nevertheless, and no one knows it better than those under him. An example proving this is shown in the following records:

S. O. No., *36*.

DATE, *Dec. 10, 1885*.

Name of parts, *Lathe bed*.
Number of pieces, *2*.
Materials, *c i*.

KIND OF WORK.	TIME.		PRICE.	
	Hours.	Mins.	$	Cents.
Planing, - - - - - - -	*22*		*10*	*00*
TOTAL, - - - - - - - -				

All completed; Employee No. *87*.

ALLISON, Foreman.

S. O. No., *68*.

DATE, *Jan. 19, 1886*.

Name of parts, *Lathe beds*.
Number of pieces, *2*.
Materials, *c i*.

KIND OF WORK.	TIME.		PRICE.	
	Hours.	Mins.	$	Cents.
Planing, - - - - - - -	*18*	*30*	*8*	*00*
TOTAL, - - - - - - - -				

All completed; Employee No. *87*.

ALLISON, Foreman.

S. O. No., *119*.

DATE, *Feb. 16, 1886*.

Name of parts, *Lathe beds*.
Number of pieces, *2*.
Materials, *c i*.

KIND OF WORK.	TIME.		PRICE.	
	Hours.	Mins.	$	Cents.
Planing, - - - - - - -	*18*	*45*	*6*	*00*
TOTAL, - - - - - - - -				

All completed; Employee No. *87*.

ALLISON, Foreman.

The price on these cards were all made out before the work began on them, and from the issue of the last one until employee No. 87 left the shop, the time never came under nineteen hours, and occasionally when some of the work was wanted badly the time was extended to twenty-five hours. I afterwards saw the same work done by the same planer hand in twelve hours, but not in that shop.

After the third cut in the piece price, No. 87 awoke to the fact that his acquired knowledge of how to set a tool, take feeds and also take advantage of time while at work, counted for naught when compared with the superintendent's ability for cutting the contract prices, and he used the only weapon of defense he had, and ceased to reduce the time for doing the work. Consequently the firm's progress ceased. I find in trial and from the wage-earners talk, that the third alteration of a price will awaken the dumbest man to the situation, and the only remedy afterwards is to get a police club and beat the profits out of them.

The following tables illustrate the workings of day-work and piece-work:

DAY WORK.

THERE IS NO OCCASION FOR ANY HURRY.

ITEMS.	1st time.	2d time.	3d time.	4th time.	5th time.
Hour rate.....	30 cts.	30 cts.	30 cts.	30 cts.	30 cts.
Time.....	10 hrs.	11 hrs.	9 hrs.	10 hrs.	9 hrs.
Total cost.....	$3.00	$3.30	$2.70	$3.00	$2.70

CONTRACT PLAN.

ONE PIECE. NOW IN USE.

ANY REDUCTION AFTER THE FOURTH TIME ANTAGONIZES AND CREATES DISCONTENT.

ITEMS.		1st time.	2d time.	3d time.	4th time.	5th time.
Time	Fixed by the workman.....	7½ hrs.	7 hrs.	6½ hrs.	6 hrs.	6 hrs.
Cost	Fixed by the foreman.....	$3.00	$2.80	$2.60	$2.40	$2.40
*Rate per hour.....		.40	.40	.40	.40	.40

* Used by the workman to figure how long he must work to avoid a cut.

Many more cards and examples could be given, but it would be the same story, nothing to be learned from them, and used only because we know of nothing better.

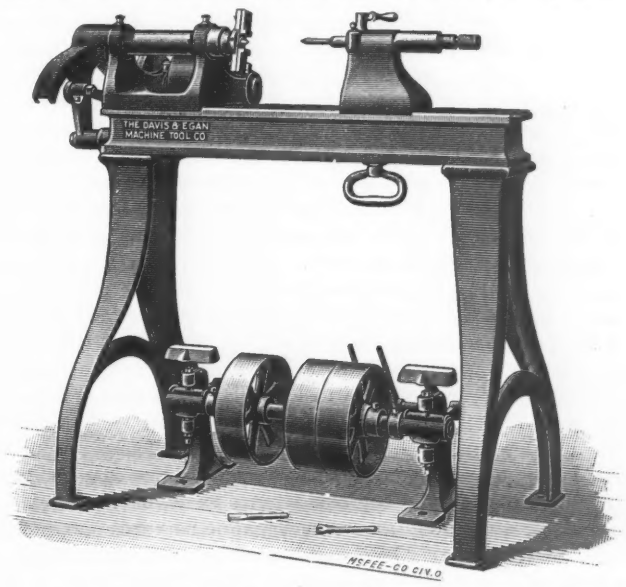
Gain sharing is a nice hobby, good only in some places and under certain conditions; and, like profit sharing, in which the "profits" are divided up once a year and the affair made prominent by a grand ball and a feast, it is a good advertising card, especially if the firm manufactures staple articles for family use.

If sales are slow, the worker in the factory, no matter how he strives, must divide his margin through no fault of his own, and the slothful workman can sometimes speed up a little and be an equal winner on division day.

* * *

DAVIS & EGAN COCK GRINDER.

The illustration shows a new machine made by the Davis & Egan Machine Tool Co., of Cincinnati, for grinding keys for steam, gas or water cocks, up to 2 inches in diameter. The spindle is rotated by a segment of a gear, giving one and one-quarter revolutions in each direction. The spindle is in a sleeve which covers its entire length, and being provided with guards to



prevent the cutting material getting into the bearings, the life of the machine is materially legthened. The crank-shaft runs in long bearings that are also protected from all cutting substances and is driven by a 10 inch pulley with a 3 inch belt. The machine is carefully fitted in all its parts, and designed with a view to producing work rapidly.

HAND-WORK IN THE PATTERN SHOP.

CISNARF

Through the introduction of new and improved tools in the machine shop, new methods have been found whereby a saving of time and money has been effected. The pattern shop has not come in for its share, and to-day, with the exception of a few little pieces, vises, clamps, etc., it stands where it did twenty years ago. Bad as this is, invariably the workmen do not have room enough to work properly, and often stand and wait their turn at a lathe or saw. There is certainly no economy in that, nor in first-class men being obliged to stop and lace belts before they can use a machine. There is too much hand-carving done in the pattern shop, machines to do special work have been designed and sought after by other branches of the wood-working trade, and why not here? Simply because it has been, and is, looked upon as a burdensome part of the machine industry, and the pest of every manager's life. It often looks as if they expected, in the near future, to be able to dispense with it, the way it is neglected, whereas, with a little interest taken in it can be made quite a light expense to carry.

One machine seldom seen is a "moulder;" this is capable of planing straight or curved outlines on four sides, simultaneously, on pieces of any length. The use of this is limited to work which is to be produced in quantities, such as fillets, ogees, half-rounds, rounds, etc., but its use spreads over an unlimited field. One practical test was made in the production of wood keys, with a taper of about one-quarter inch to the foot on the side A.

Originally these were made separately, when one was wanted or fifty; each piece was worked out by hand at enormous (comparatively) expense. A "moulder" was purchased, also flat "irons," or cutters, for the flat sides, one set doing for all sizes of key. The tool-maker made cutters for the side A, each size having a separate cutter. A thousand feet of each size were made at once and kept in stock. When a man wanted a key he cut off the long piece, a little more than he needed, put it in a vise, where it rested on a block, pitched the amount of taper needed, then took a couple of cuts off the side opposite A, getting the proper taper, then squared up the ends, and the key was finished. This was a financial success, and is but one of the many uses of this machine.

A machine called the variety wood-worker is an upright spindle revolving in the center of an adjustable table; this is a time-saver in finishing holes in frames, shaping gear-arms, etc. The knives are the only objectionable feature, but once made are always ready, and the second time used will pay for their cost.

A third machine, which I have never seen in but one pattern shop, is a "mortiser;" it is merely an upright, reciprocating chisel. The work is put on a table under it (which is adjusted with the foot), held and shifted with the hands, for working out "pockets" in a pattern, or in any case where it cannot be sawed out; it can do the work of five men. With care and experience, a man can work up to within a sixteenth of the line, leaving but a finishing cut to be made by hand. To rough out a large circular hole, it is also much quicker than hand work. It is a wonder, when "short cuts" are so much sought after in drawing-rooms and the shop that their influence does not affect pattern-makers. See what labor is spent in making a simple circular core-print; wouldn't it be more profitable to let a boy make a lot of different sizes, each even inches in diameter? Then nothing is left to do when a man wants one but to nail it in place. The time spent in sorting lumber and getting the piece ready is more than the labor of turning; if desired, they could even have them painted. A machinist doesn't make a screw every time he needs one, neither should a pattern-maker be obliged to make every little auxiliary he needs and work it out by hand.

* * *

ONE of our mechanical friends says: "You cannot drive a drill to the limit of its capacity with a friction chuck. See that your workmen flatten the ends of your drills or use some positive driving method. It will save you money, and them annoyance."

MATHEMATICAL POINTERS FOR DRAFTSMEN AND MECHANICS.

J. BEGTRUP.

Mathematics can be learned in schools and from books, but to apply mathematical knowledge to practical problems in the office or shop, that is, to make use of it in machine design and construction, is an accomplishment quite distinct from a thorough mastery of the abstract science. It cannot be learned from books, it can only be acquired by practice, as I know from personal experience. If we have to look in a book every time we want to make some calculation, and must write down formulas and long strings of decimals, we shall soon be disgusted with our mathematics, and let it pass away with other youthful dreams of beauty and perfection.

It is first of all necessary that our mathematical knowledge shall have a solid foundation, furnished by nature itself, born in us. He who has no natural faculty or inclination for mathematics will not make much progress as designer, architect, draftsman or mechanic, and he who has the natural faculty can only make it of any *special* value by hard study and extended practice. He who looks on mathematics as a pastime, although he may be a good mathematician, will hardly make much practical use of it.

The practical man *must* learn the fundamental principles well. With him these principles are of far greater importance than a mass of figures and formulas only half understood and very seldom of any use in practical everyday designing. Such elaborate mathematics can only be used and applied correctly by expert mathematicians, and they are few. Much of so-called mathematics now found in current literature is therefore wrong or useless. Great exactness in the calculation of weight, strength and capacity of machine parts is hardly ever necessary. As a rule, the first calculation before the design is finished need only be in the nature of a rough estimate, and it would be a waste of time and mental labor to attempt a close calculation before the design has progressed far enough for accurate detail drawings to be made; and in many cases the exact figures will never be required. Such calculation can often be made. without writing down any figures, by a simple mental process. It may, for instance, be made while talking about the matter to some other interested party by a little pausing in the conversation, or it can be made while making a sketch or working drawing of the object. The required proficiency can be had by repeated attention to certain simple rules and principles, but it also requires some emancipation from the exact scientific teaching of the text book It is a sort of abbreviated mathematics which cannot safely be used by those who cannot "see through it," or who have not the fundamental knowledge which enables them to discriminate in the use of it; but it is the only mathematics of any use in everyday practice.

The present article is written with the object of helping those who have a real and earnest desire to obtain proficiency in the practical application of mathematics to machine design and construction. It is not a treatise on the subject, but merely a few hints or pointers.

In the first place the parts considered must be reduced to simple approximate forms or geometrical figures, or an assemblage of such forms and figures, and then each of these calculated separately. Prismatic forms and flat plates are most common. The section of a prismatic element is nearly always of retangular, circular, or elliptical form.

The circumference of a circle is $3\frac{1}{7}$ times the diameter.

The area is $\frac{3}{4}$ of the diameter squared and a little more; this "little more" is $\frac{1}{20}$ or 5 per cent. of the product, which may be added when great accuracy is desired. The diameter squared means one diameter multipled by itself.

An ellipse has two diameters, and its area is $\frac{3}{4}$ of the long diameter multiplied by the short diameter plus $\frac{1}{20}$ or 5 per cent. of the product.

The areas of circles are proportional to the squares of their diameters. This rule is useful when figuring the capacity of piping, chimneys, cylinders, etc.; for instance, an 8-inch pipe has four times the capacity of a 4-inch pipe, and the collective area of a 4-inch and 3-inch pipe is equal to the area of a 5-inch pipe.

Another useful rule which should be remembered is this: A small addition to the diameter gives twice the proportional addition to the area. For example, the area of a 12-inch pipe = 12×

$12 \times \frac{3}{4} + 5$ per cent. $= 108 + 5 = 113$ square inches. A 13-inch pipe is $\frac{1}{12}$ larger in diameter and therefore $\frac{1}{6}$ larger in area, that is, $113 + 19 = 132$ square inches. The error in this case is .7 square inches; but if we had added to or subtracted from the diameter only ½ inch, the error would be quite inappreciable.

If we have an 8-inch pipe and it is desired to increase the capacity by one-quarter, we must increase the diameter by an eighth, making it 9 inches. The method is sufficiently accurate for steam pipes and always accurate enough for a rough estimate, and it is more convenient than to hunt up the figures in a table of circles; for first the book must be found, then the table and finally the figure. The method can also be used as a check on

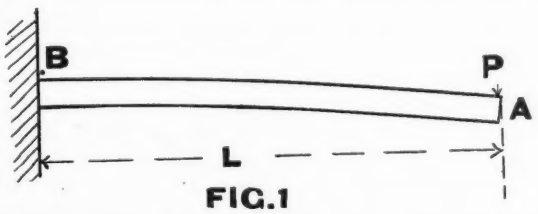


FIG. 1

more elaborate calculations. The cubic contents of a ball is one half the diameter cubed and a little more, or in symbols $\frac{1}{2} d^3 +$, this "little more" is again $\frac{1}{20}$ or 5 per cent. of the product; and a small addition to the diameter gives a little more than three times as large proportional addition to the cubic content. For example: The cubic content of a 6-inch ball is $\frac{1}{2}\ 6^3 + = 108 + 5 = 113$ cubic inches; if we add ½ inch to the diameter we increase it by $\frac{1}{12}$, and the increase in cubic contents will therefore be a little more than ¼ of 113, or 29 cubic inches. Any simple formula will easily be remembered if we have worked it out and know *why* it is correct, and it is best to use simple formulas only.

It often happens that we have a fraction in decimals which we want to make into eighths and sixteenths; this is done by multiplying by 8; for example, $.435 = 3.48$ eights $= \frac{7}{16}$.

How much will it weigh, is a question often sprung on a draftsman or foreman, and then a little lightning calculation comes in handy and enables us to make a good "guess." The weight of cast iron is a little more than ¼ pound per cubic inch. This "little more" amounts to 4 per cent., which may be added at the end of the calculation. Wrought iron and steel are about 7 per cent. heavier than cast iron. Lead is 58 per cent. and brass about 13 per cent. heavier than cast iron.

The safe load for cast iron is a rather uncertain quantity. To guard against hidden defects in the casting a high factor of safety should be used. He who has much *general* experience with cast iron calls it "treacherous," and it is well to heed the warning of an experienced man. Where special attention is paid to the mixture, the heat, the molding and casting, a smaller factor of safety can be used. Cast iron can stand an enormous compressive strain, but the *average* ultimate tensile strength is only about 16,000 pounds per square inch of cross section. The safe working load in each particular case depends on good judgment and experience. It will not do to increase the strength every time a part of a machine breaks, for then we should finally arrive at abnormal and absurd dimensions.

The exact condition under which a break occurs is seldom known; the testimony of an attendant cannot always be depended

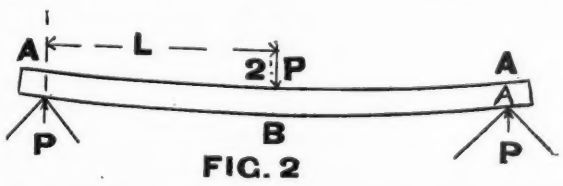


FIG. 2

upon. The break is often caused by faulty workmanship, which brings undue strain on a particular part. The broken part should be carefully examined to discover any old fracture.

In many cases the stiffness or rigidity required will govern the design, and the part will be much heavier than needed for strength. The designer should consider what will happen if any particular part breaks; what it will cost by interruption of business, damage to property, injury to the attendants or the public, whether a duplicate can easily be had, etc.; and it is well to remember that cast iron is cheap. When calculating the strength of wrought iron or steel we may go closer to the limit, for the material is generally homogeneous and flexible, and unexplainable failures are rare. Good wrought iron has an ultimate strength of 50,000 pounds per square inch, and 8,000 pounds is a very safe working load. Machinery steel will stand at least one half more.

The chains of cranes and hoists should not be loaded over 8,000 pounds per square inch of cross section. It is exceedingly easy to calculate the safe load on chains, and there is no excuse for allowing them to be overloaded, which, however, often occurs and sometimes results in serious accidents. Example: How much will a double sheave chain of one-inch iron carry with safety? Here the load is carried by four chains, each having a sectional area $= 2 \times \frac{3}{4} + = \frac{3}{2} +$ (the addition sign means 5 per cent. to be added). The collective area is $4 \times \frac{3}{2} + = 6 +$, which, multiplied by 8,000, gives a safe load of 48,000 pounds + 5 per cent = 50,000 pounds. How much will a single sheave chain of ⅝ inch iron carry with safety? The sectional area of ⅝ inch iron is $\frac{3}{4}(\frac{5}{8})^2 + = \frac{3}{4} \times \frac{5}{8} + = \frac{9}{8} +$; this makes the collective area of two chains $4 \times \frac{9}{8} + = 1\frac{1}{4}$ nearly, which, multiplied by 8,000, gives a safe load of 10,000 pounds. Also by comparing the square of diameters we should find that a ⅝-inch chain will carry a little more than three-eighths of what a 1-inch chain will carry. It would *probably* be perfectly safe to increase the figures here given by 10 per cent.

When a certain factor becomes twice effective or effective in two directions at the same time, its power or potency is doubled, which in mathematics is denoted by an index, as d^2. Any plane figure may be considered as an area expanded from a point in two directions. If we consider the area of a circular sector it will readily be seen that if we add to the radius the sector will be longer, but also the longer the radius the wider the sector, the width being simply proportional to the radius. The radius is therefore a quantity which is twice effective in regard to the area of the figure; and as the whole circular area is composed of sectors, we have the expression $\frac{3}{4} d^2 +$ for the area of a circle of any diameter. In a solid, as a ball, the expansion takes place in three directions, hence the expression $\frac{1}{2} d^3 +$ for the cubic content

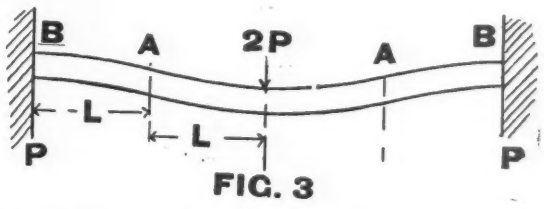


FIG. 3

of a ball. This is a fundamental principle which should be well understood, for it helps one to remember the indexes, which are of primary importance in all formulas, for on these indexes depend the comparative magnitudes of similar quantities, which often is all that is wanted. This is also of great importance when we use formulas for transverse load or deflection. Most problems of this nature in machine design may readily be reduced to the simple case of a beam fixed at one end and loaded at the other end. Fig. 1 represents this case.

The load P is applied at A, and the bending moment at B is expressed by the product P L. In Fig. 2 the beam is supported at both ends and a load 2 P applied at the center. At each end we have an upward reaction P, and the condition is exactly as if the beam had been supported in the center and a load P applied to each of the free ends. The bending moment at the center is therefore $= P \times L$. In Fig. 3 the beam is fast at both ends and deflected by a load 2 P in the center. There will be an upward reaction P at each end and there will be two points of inflexion at A corresponding to points A in Figs. 1 and 2, and the moment of bending at the ends and at the center is $= P L$. It will be seen that case 1 only need be considered here, and as additional formulas for the two other cases are apt to make confusion, they should not be admitted in practice. The bending moment P L calls into action a resisting moment of equal magnitude in the material of the beam; the upper part is in tension and the lower part is in compression, and there is a central horizontal plane called the neutral plane. Particles on each side of this plane will be extended or compressed in direct proportion to their distance from the neutral plane and the leverage of internal or molecular resistance to bending will be in the same proportion. Now the higher the beam the further the material will be removed from the neutral plane and at the same time an increase of height increases the area of cross section. The height is therefore a twice effective quantity.

By increasing the width we increase the area in the same proportion, but the distance from the neutral plane remains unaltered; the width of the beam is therefore a quantity of one degree of effectiveness or power, and therefore in the formula for transverse resistance we find only the height squared.

$$P \times L = \frac{W H^2}{6} \times C$$

is the formula for a rectangular beam fixed at one end, where C is tensile stress per square inch of material; W is the width and H is the height. A small proportional addition to the height will increase the strength twice as much proportionally. For instance, a beam 6 inches high will be $\frac{1}{6}$ stronger if we add ½ inch to the height. If a round shaft is subjected to a bending strain the formula becomes

$$P \times L = \frac{d^3}{10} C,$$

where d is the diameter. What will an 8 inch steel shaft 10 feet between supports carry at the center with safety. Here

$$P \times L = \frac{8^3}{10} \times 14{,}000 = 716{,}800 \text{ and } P = \frac{716{,}800}{60} = 11{,}950.$$

This is only half the weight; the shaft will carry with safety 24,000 pounds. A small addition to the diameter adds a little more than three times the proportional strength. For instance, if we increase the diameter of the shaft to 8½ inches we add $\frac{1}{16}$ of the diameter and therefore increase the carrying capacity to $24{,}000 + (\frac{3}{16} \times 24{,}000) + = 24{,}000 + 4{,}500 + = 28{,}500+$.

Resistance to wrenching of solid shafts is calculated from the formula

$$P \times R = \frac{d^3}{5} C.$$

where P is the wrenching force and R its distance from center of shaft. In this formula the diameter is of the third power, which will readily be understood when we consider the shaft is composed of concentric rings. An addition to the diameter increases the area and also the leverage of resistance, but the resistance will not only increase on account of greater leverage, but also on account of the increasing length of circular strata, which makes the diameter a three-times effective quantity; and a small addition to the diameter will give a little more than three times proportional addition to the strength.

The principle of indexes or powers here referred to can with advantage be applied to the more complex formulas for deflection of springs, etc.; but I shall leave this to the reader who may wish to give the matter special attention.

* * *

REPAIRING AND SHIFTING ECCENTRICS.

W. H. WAKEMAN.

A correspondent writes me that his eccentric is worn and that it heats while his engine is running, although he has repaired it to the best of his ability with the materials at hand. As this is a matter that interests almost every engineer in charge of a steam plant, a few suggestions may be of value to readers.

As ordinarily designed and built, eccentrics have sufficient wearing surface to prevent undue friction under full load, consequently they should not heat and the wear ought not to be excessive. Sometimes engines are so designed that the eccentric forms a collar on the crank shaft, and so its position close up to the main bearing is arbitrarily fixed, and if the rocker arm or rock shaft is not exactly in line with it then the strap will not bear equally on all parts of the eccentric, but will have only a very narrow bearing on each side and so will heat. If the position of the eccentric is not arbitrarily fixed, lengthwise of the shaft, then the engineer may have moved it out of its proper place, when turning it on the shaft for some purpose, hence the trouble.

A good way to determine if this is the cause of it is as follows: Uncouple the eccentric rod from the rocker arm and move it sidewise as far as it will go in opposite directions. If it swings to equal distances each side of the bearing on the rocker arm, it is good evidence that the eccentric is in line. If the strap fits so nicely that the end of the eccentric rod cannot be moved sidewise, and there are liners between the two halves of the strap, then remove these liners and draw the strap down tightly on the eccentric. Note the position of the end of the rod and if it is not in line with the bearing on the rocker arm, then move the eccentric until it does come in line. A consideration of the manner in which the eccentric does its work, will show that it will not wear evenly, consequently it may rattle at a certain part of the revolution of the engine. In this case it will not be safe to take out liners and screw up the nuts without due care, or else the rod or the eccentric strap may be broken when the engine is started up. In all cases where it is possible to do it, the rod should be loosened from the rocker arm, after the strap has been adjusted, and turned by hand through half a revolution around the shaft and care taken to note if it binds in theslightest degree at any point. If it does, then the strap must be loosened up, or the eccentric filed down until it moves around perfectly free. Generally a quarter of a revolution will answer every purpose, but half is better if it can be done. Sometimes if an eccentric rattles slightly when oil is used as a lubricant, the substitution of grease will have a good effect.

Sometimes an eccentric is worn so badly that it is necessary to turn it down and make a new strap for it. The question then arises as to whether it will have the same throw as formerly or not, and working engineers who have not designed engines, sometimes do not readily see that the throw is not affected by the reduction of outside diameter. The easiest and most satisfactory way that I have found of illustrating this is to take a board say one half inch thick and saw out a circle representing an eccentric. Next saw a piece off from this, reducing the circle by 2 inches or 1 inch on a side and save the piece so removed. Now bore a hole through the eccentric and by means of a screw fasten it to another board, said screw to be located say 2 inches from center of eccentric so that it may represent the crank shaft. See Fig. 1. Revolve this eccentric around the screw and note the throw of it, when it will be found to be the same, either with the 1 inch piece in position, or with it removed, which plainly demonstrates that the throw is not affected by reducing the diameter.

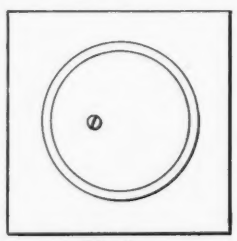


Fig. 1

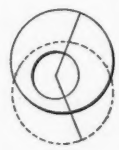


Fig. 2

When giving directions concerning reversing an engine, I formerly said that it was proper to move the eccentric in the same direction that the engine is to run, until the valve has the proper lead, etc. But I have reformed, and now say "move it in the opposite direction from that in which the engine is intended to run." The cause for this change of opinion was an eccentric that moved very hard on the shaft, so that the heavy blow with a sledge would move it only about one sixteenth of an inch. Under such circumstances it makes quite a difference whether you move it the shortest way or the longest. A glance at the sketch Fig. 2 will make it plain. The full lines represent the position of eccentric for running in one direction and the dotted lines for the other. If we move it in the same direction that the engine is to run, then we must move it the longest way around the shaft, but if we adopt the opposite direction as correct, then we will move it the shortest way. If the eccentric moves easily, then it makes no difference which way it goes, but if it goes hard, then it makes a great difference. In either case the truth of the setting must be proven by an application of the indicator.

* * *

THREW THE BELT OFF.

"Ever hear how I went into business and how I got out again?" asked Uncle Dan Blooker the other day. "Well, three of us machinists got the idea we wanted to go into biz, so we left the old concern and hired a room about 35 by 40 feet and took power from a shaft sticking through the wall. Called ourselves Adams, Blooker & Cook Co. We found profits wouldn't much more than satisfy two, so Adams and I threw off the belt one morning before Cook arrived and waited. We told him the trouble and also gently and firmly that the belt didn't go on till he sold out to us—mostly on our note. Then it was Adams & Blooker. Adams got to thinking he ought to have a partner with more money, so he induced Lackey to go in with him and then he *threw the belt off on me*, which wasn't quite so funny as it was the first time—at least not for me. The other day I heard that Lackey had gone in with another man and *thrown the belt off* on Adams, which sort of evens things up, as much as such events can. Now I am wondering who throws the belt off next time."

NOTES FROM NOTOWN.

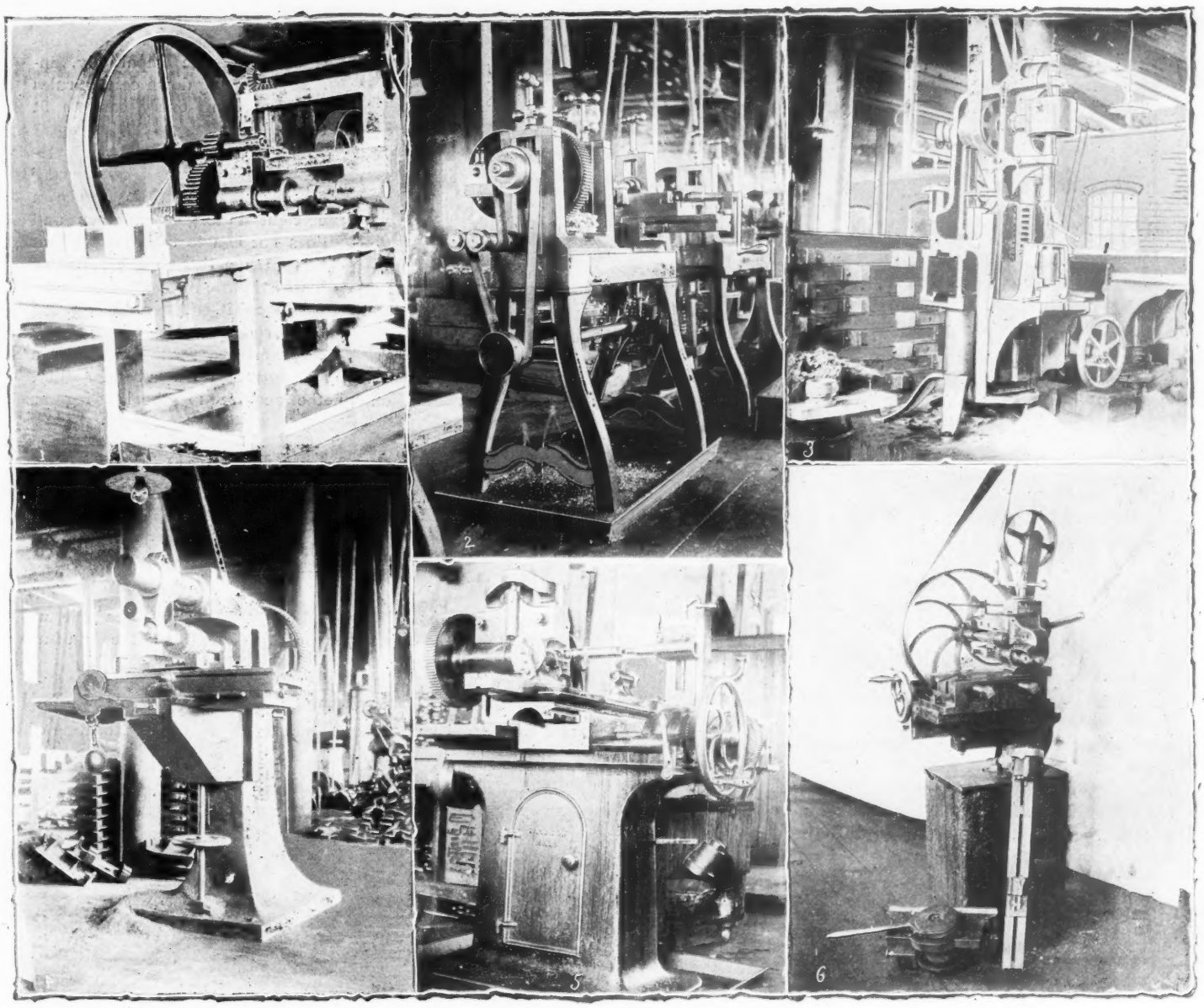
SETTING UP POOR WORK.—IF I WERE BOSS.

ICHABOD PODUNK.

There have been several changes in the Sterner Mfg. Co. in the last few months and, owing to dissensions of the stockholders, agitated by the old superintendent, Frank Jones, the new man is out of the shop, for the present at least. He would have left altogether but for the president, who knew the old super would kill himself if he only had a chance. So he was sent out as superintendent of construction, setting up work in different parts of the country. All went well for awhile and then there began to be trouble over work not fitting, same as under the old management before. Of course the president heard of it and chuckled to himself, as he knew it meant a victory later on. So he wrote Jones to make out a list of defects and have them ready when he returned home.

When Jones arrived he was called to the office and found the old super and some of the directors awaiting him.

"Well, Jones," said the president, trying to be stern, "you have been making numerous complaints about these last engines, now we want to know just what the trouble is and whether it is your fault or ours, as the reputation of the Sterner Mfg. Co. must be preserved at all hazards. Now, Jones, what was the main trouble with the engine?" "That's hard to say," says Jones, "there were so many things that prevented the engines running at all that they could probably all be called main troubles." "But can't you tell us just what parts gave trouble, for we haven't long to discuss this little question?" "Then I better give you a list of the parts that were right," said Jones, "that won't take as long as the other," and here he pulled a sheet of foolscap out of his pocket, "might take sometime to go into details, and details count when it comes to setting up an engine. The castings, oil cups, bolts and nuts, in fact about all the things we buy were all right, but when it comes to the engine and its auxiliaries the trouble commences. I'll just run through the list to show you what changes can occur in a few months, but let me say right here that I don't want my old position again, wouldn't take it at any price you could pay, and that the first of the month I go with the —— —— Co. as mechanical engineer." The super breathed easy to know Jones wouldn't come back, but he was ready to scalp him before he got through the list. "Go on, Jones," said the president. "Commencing with the cylinder, we found that the piston wouldn't pass the valve plugs, showing it had not only never been turned over in the shop but the valve holes were bored so as to break through into bore of cylinder, which wasn't discovered by the inspector. The piston rod nut was such a loose fit as to be unsafe, and I had a new one made. The oil pockets in the pillow block cap had never had the core sand cleaned out and would have made nice work of the main bearing if they had been left that way. The air pump was packed so tight that it couldn't be moved with a sledge hammer, and the lever, which was to drive it, was so crooked it wouldn't lay still—evidently being bent the wrong way first and then mauled with sledges after being ready to ship. One crank pin was not forced in straight

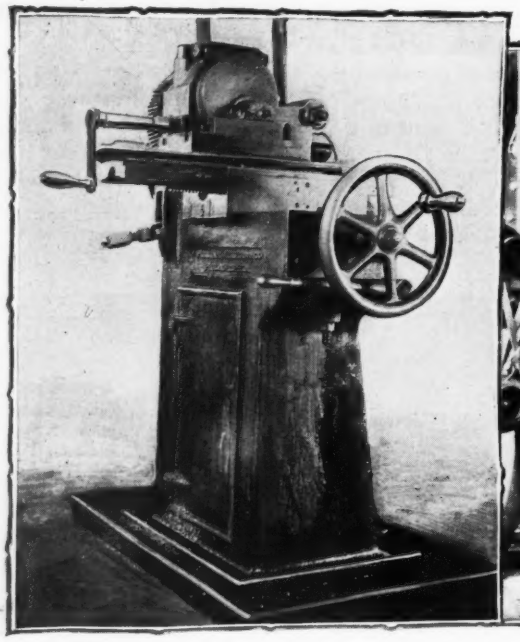


1—OLD SLABBING MACHINE.
2—LINCOLN TYPE.
3—OLD VERTICAL MILLER.

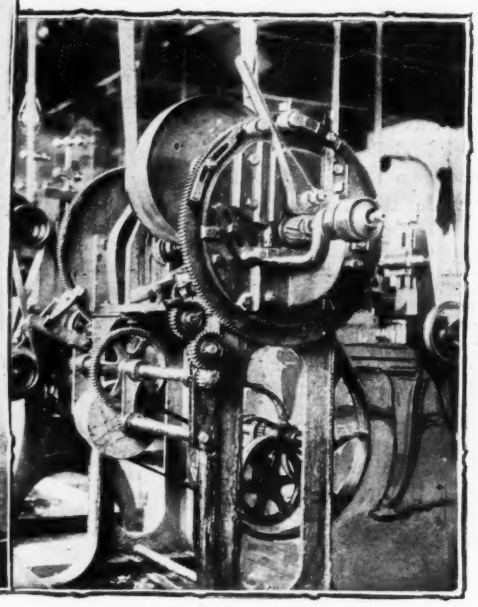
SOME EARLY MILLING MACHINES.—SEE PAGE 221.

4—KNEE TYPE—ENGLISH.
5—MASON MILLER.
6—OLDEST MACHINE FOUND.

and had to be dressed with a file to bring it square with the crank, taking two days. One"—. "Hold on, Jones," said the president, "I've heard enough, and I hope the other directors have also. If half you say is true, and there's no doubt of that I guess, we better get a good man to look after the shop or quit business. Who would you recommend Jones?"



NO. 6—OLD SELLERS MACHINE.



NO. 7—PACKARD MACHINE.

SEE PAGE 221.

But Jones wasn't recommending any one; he knew the president's good intentions and he also knew that, as he didn't hold the majority of the stock, he couldn't say who should be the man or that he should be let alone.

This is no fancy sketch, as Jones is a friend of mine and told me what happened, and I also know that the defects he mentioned were actual facts. The Sterner Mfg. Co. is not the only one in which this condition of affairs exists.

If I were boss instead of one of the hands, I would be very careful in the selection of tools and not buy any combination machines, as I said last month, unless it was a job shop and I couldn't afford two machines.

It is very easy to buy a tool, if the agent is a good talker, and decidedly hard to dispose of it if you find you don't want it. Five minutes in your shop makes a second-hand tool of it—even if it is never run—and you must knock off a good slice of price to get rid of it at all. I wouldn't have lathes which were so light that the bed springs if a fly lights in the center, as some I've seen will do; but would have plenty of metal, even if some was in the wrong place, so long as there was enough in the right place to prevent undue springing.

I would have each tool which handled work weighing 50 pounds or over served by a crane, hand power in ordinary shops, compressed air if I could induce the firm to put in a belt driven compressor, which runs without much trouble and the power required can usually be saved by looking after the line shafting a little more closely than is usually done. As to lathes for regular plain turning, such as piston rods, valve stems, etc., there would be no fancy work, no unnecessary adjustments, in fact a lathe for plain turning only and no attachments for anything else. Planers would have a greater ratio between belt and table speed than is commonly found, not only to enable heavy cuts but to assist in making the cuts smooth, which is helped by having the power steady instead of spasmodic. Planers for special jobs would be just large enough for that work and no larger—so as to prevent their being used on heavier work and to partially insure their being ready when wanted.

Belts should be looked after and not allowed to run with torn lacings or belt holes, and provision made to prevent belts from dropping in between pulleys, where they can catch and raise Cain generally, sometimes pulling down the line shafting and causing nervous disorders in the workmen who run machines in that vicinity. I know this from experience.

Then I'd inspect castings before there was much if any work done on them, as I know of more than one case where this would have saved dollars, to say nothing of the time on a contract job with a forfeit attached. Of course some defects will not show until a cut is taken, but that only argues for another inspection after making the cut instead of omitting the first one. This isn't an iron bound rule to be followed in all cases, but applies to work where the cost of inspection is less than the loss is likely to be in case of a bad casting, which is usually the case where the casting is fairly heavy. The foreman, or whoever is in charge, should know where to draw the line, if he doesn't he isn't the man for the place. In fact, it will usually be found that the most successful managers are those who exercise good judgment and consider each case separately, instead of laying down certain rules and squeezing every case to fit them.

A technical education helps materially in solving and considering shop problems, but it is merely an efficient aid to good judgment and does not enable the man without this qualification to get ahead of his unlearned competitor who possesses it. After all, as has been remarked by others, good engineering is for the most part a matter of good judgment, which depends upon natural ability, experience and education, whether acquired in school, college or at home.

* * *

AN EXTRAORDINARY EXAMPLE OF POWER TRANSMISSION,

WHICH IS WELL TO KNOW ABOUT, BUT NOT WISE TO FOLLOW.

JOHN H. COOPER.

Examples are generally worked out by rule; in this case, let us see what kind of a rule would be established upon the data furnished by this example.

It pays sometimes to find out the greatest load that a machine, or any organ of transmission will bear, providing you are not put to the expense of a new one, as a charge upon the gratification of your curiosity.

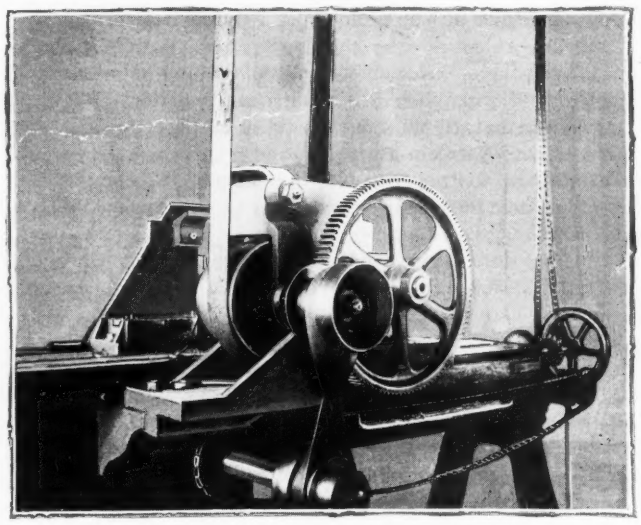
Of this motive plant, the location, ownership and expenses will not be noted here; it being sufficient for the object in view, to give the data and results which belong to its make-up and performance.

NO. 4—ANOTHER SLABBING MACHINE. SEE PAGE 221.

Let us follow the advice of the poet, reasoning from what we know, presuming not the judgment of others to scan.

If we succeed in making this a clear case of "how not to do it," that much is at least gained, and a note of warning sounded, which is all the noise we propose to make at this writing.

The case to be reported, in this article, is that of a certain Corliss engine, having an 18 x 36-inch cylinder, running 100 Rpm,



NO. 5, DETAIL OF HEAD OF SLABBER.—SEE PAGE 221.

and indicating 250 horse-power. This engine, when cutting off at a ¼ the stroke, should have developed about 175 horse-power. Within the knowledge of the reporter, this engine continued running under the load named during a period of two years, but required great care and constant watching.

The fly-wheel pulley was 12 feet diameter, and carried an 18-inch double leather belt, which ran over a 5⅓ feet diameter-driven pulley, which was located 25 feet horizontally away (from center to center), its center also 14 feet 8 inches above the center of the engine shaft.

As the top fold of the belt was the driving one, the slack of the lower fold was taken up by a 36-inch diameter tightener, applied near to the fly-wheel. In order to find the tension to which each inch of width of this belt was subjected, from the data given,

$$\text{we have } \frac{250 \times 3\,300}{3\,770 \times 18} = 121.57$$

which result gives the number of pounds per unit, to which this belt was drawn to carry the power indicated. The reporter says that 4 feet of length was cut out of this belt in less than six months of such use.

Now we do not know exactly what quality of leather was in this belt; it must have been pretty good, however, to stretch so much and still hold on.

The ultimate strength of belting leathers by test, per inch of width, varies from 507 lbs. when $\frac{3}{16}$ inch thick to 1,250 lbs. when ¼-inch thick, and as double leather belts are not always made up from the best and thickest stock, it would not be safe to name the ultimate of some doubles anywhere near the highest tensile given above.

The next point to consider is the proper *factor of efficiency* for leather belts. Of course, this is best derived from experience and must be based on the materials; of which, take such examples as these: Old English rules for the strength of cast-iron teeth of wheels provide for a factor of safety of 15, while modern boiler practice protects boiler plate by a factor of safety of 5. The first covers the uncertainty of strength to which castings are liable, a very necessary precaution with this material which we all know; the other is found safe in practice because of the greater certainty of a quality in the materials used, which have been proved to be nearly uniform. It is just here, and for good reasons, leather should be grouped under the head of materials, having even a wider range of tensional quality, to which the figure 20 would rationally apply and not prove too large a margin for safety, especially when used on belting of unknown quality.

Let us illustrate this by taking the best material named above, and assume the belt in question made of two thicknesses of say 3-16 inch each, and apply a factor of safety of 20, we will then

$$\text{have } \frac{1\,250 + 625}{20} = 93.75 \text{ lbs., the maximum}$$

safe working pull of such a belt, and if we make it of the ordinary stock named above—that is 507 lbs.—we have:

$$\frac{507 + 507}{20} = 50.7 \text{ lbs.}$$

The mean of these is 72.22 lbs. The strength of leather given above represents actual tests, and the belt at work on the engine quoted is actual also; now a F. of E. is an assumed margin, based upon the existing range of quality, but does not this extraordinary example prove 20 to be a safe one. Since this belt, presumably of good material, was greatly deformed.

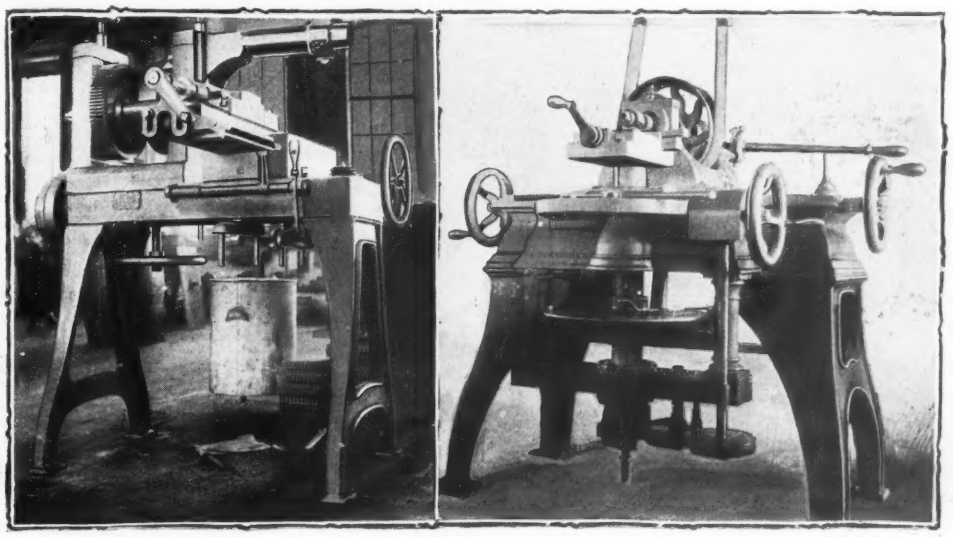
Many rules given by good names, such as Marin, Armour, Sturtevant, Appleton, Unwin, Box and others, which are certainly based upon good materials (there can be no safe rule founded upon bad materials, nor bad workmanship either), these give from 300 to 355 lbs of safe stress upon a square inch of section of leather. Applying these to a double belt ⅜-inch thick, we will get respectively 112½ lbs. and 133⅓ pounds, the permissible working strain. We see, therefore, that if the authorities quoted be reliable, the belt was not of the best.

* * *

SHRINKING FITS.

There is considerable diversity of opinion regarding the proper amount to allow for making "shrink" fits, and we give a formula by a French authority in the *Railway Car Journal*, of September, 1895. This considers the center of the wheel (in the case of a driving wheel) to be incompressible and allows $\frac{1}{1\,000}$ of the diameter for shrinkage, *i. e.*, to bore the ring $\frac{1}{1\,000}$ smaller than the diameter of internal piece. In the case of a piece 4 inches in diameter, the ring is bored 4 inches minus $4 \times \frac{1}{1\,000}$, or $4 - .004$ or 3.996 inches. Calling E the co-efficient of elasticity, equal to 28 000 000 pounds, the writer gives the formula that $\frac{1}{1\,000}$ of $D = \frac{R}{E}$ or $\frac{1}{1000} = \frac{R}{28{,}000{,}00}$ or R (the initial tension on shrunken ring) equal $R = \frac{28\,000\,000}{1\,000} = 28\,000$ pounds, about half the breaking load for wrought iron.

Using this same formula it will be seen that for cast iron the allowance will be considerably less owing to the low limit of elasticity and breaking strain. Taking the co-efficient of elasticity of cast iron as 18 000 000 pounds and the breaking strain as 33 000 pounds and dividing this by 3 for a safe working strain (although even a greater factor of safety might be more desirable in many cases, owing to liability of internal defects in the metal), and we



NO. 8, COLT MACHINE. SEE PAGE 221. NO. 9, ANOTHER LINCOLN MACHINE

have 11 000 pounds in the safe working strain. Then $\frac{R}{E}$ = the allowance for shrinkage, or $\frac{11\,000}{18\,000\,000} = .0006$ of diameter, or on a 10-inch cast iron collar we have $.0006 \times 10 = .006$, which agrees very well with practice. The formula agrees very closely with the standards adopted by the railway master mechanics for shrinking on locomotive driving wheel tires. C.

* * *

HOW TO ADVERTISE.

Wm. H. Ridgway.

When any one after an expenditure of thought, time and money has succeeded in perfecting a machine or any other article of merit, the next thing he usually desires to do is to manufacture and sell it. In order that people may buy this machine or article from him he must let those who have use for it know in one way or another that he has it for sale.

This letting people know is what we understand when we speak of advertising. It has been called the Art of Advertising, although as a matter of history the most effective advertising has usually been perfectly artless.

In probably no other line of human activity, engaging the attention of smart and able men, has so much money been wasted, and is still being wasted as in the endeavor to advertise wares. As the readers of this journal are for the most part interested in mechanical matters, let us take the manufacturers of machinery for example.

It seems to be the general opinion of those who make use of the trade papers to reach their customers, that all they have to do is to print a cut of the machine, the statement in some form or another of the old time-worn phrase, "The best in the world," and the name and address of the firm in good big black letters, and they have advertised the machine. There are hundreds of establishments to-day carrying such advertisements in various first-class trade papers, and most, if not all, of these concerns are satisfied they are getting very small return for their expenditure of money. Indeed they would stop their cards at the first opportunity were it not that their competitors carry similar cards in the same papers, and they fear they might lose prestige if they should drop out.

In most, if not all the trade papers the advertising patronage is held almost entirely by the constant solicitation of the vigilant advertising solicitor and the skilful playing of one competitor against another. When the advertising solicitor calls, the best thing he can do is to point out all those in the same line of business who carry cards in his paper, and if this does not succeed in making a new contract or renewing an old one, nothing else he can offer will. But few advertisers, in the machinery line at any rate, carry a card in the trade papers solely because it is the most efficient salesman they can get and because it brings in orders that may be seen and counted and credited to the issue of the paper.

This is not in the remotest degree the fault of the trade paper. The good trade paper which has a constituency who subscribe and pay for it, is a godsend to all makers of machinery used by that constituency. It offers a cheap and efficient medium to speak to these people every month or every week, as the case may be. If advantage be taken of this opportunity by the machine maker in an intelligent manner, he can make those who have use for his machine even more familiar with it than if he called upon each one of them personally.

He cannot of course do this unless the people who get the paper are pleased to read what he has to say. His announcements must not be ordinary. In all trade papers there are dozens of ordinary advertisements; in fact nearly all the cards are very much alike: a cut, a puff, a name and address. So no matter how pretty the cut, how eloquent the puff, or how big the type of the firm's name, it attracts but limited attention. No more indeed than the man in a high silk hat in the company where all wear high silk hats.

Hence, the first thing the advertiser desires is that the readers of the paper shall turn to and read what he has to say. In order that they may turn to it the card must be of such a size that it may readily be found. It must be of liberal dimensions as compared with the other cards in the paper. Sawdust cards in a trade paper which goes to high-pressure busy men are almost a pure waste of money. Besides, there is always something impressive in mere size, and a big prominent card naturally implies a first-class, wide-awake, up-to-date establishment, even if it does not always follow.

Having selected a good big card that the reader can find without undue effort, the advertiser must now have every patron of the paper, on the receipt of each issue, turn to the page upon

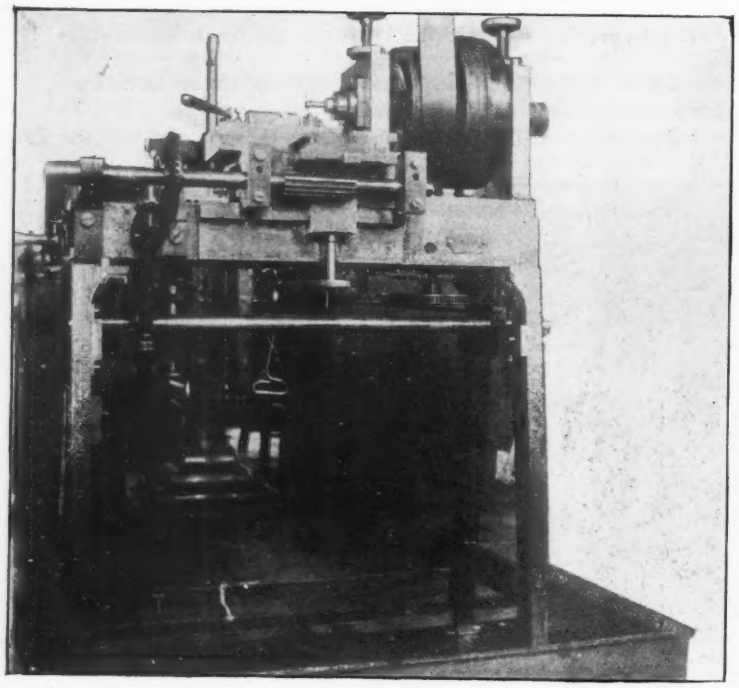


FIG. 2.

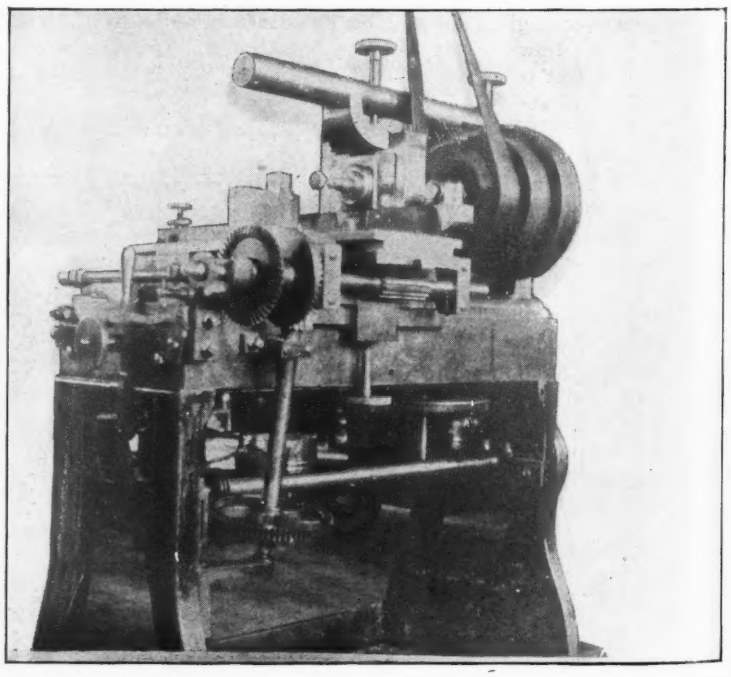


FIG. 3.

SOME EARLY MILLLING MACHINES.—SEE PAGE 221.

which it regularly appears, to see "what Brown has to say this week."

Now comes the tug of war. What shall Brown say each week and how shall he say it? Shall he employ a professional advertisement writer? Never, unless the professional writer has that rare gift of changing his personality for the time, into Brown's; just as Joe Jefferson can become Rip Van Winkle for an evening. No coat will ever fit Brown like his own coat, and an advertisement to be interesting and attractive and command attention, must have individuality just as men must have individuality to command respect and attention. It must be different from any other advertisement printed by any other man in any other paper.

To attain this individuality, which is so vital for the success of the advertisement, let the man who "got up" or perfected the machine get up the card. Let him tell about his machine in the same way and in exactly the same words as he would did he have his reader face to face with him in his shop or office. If he is a man of culture he will do it in a cultured way. If he is a plain, practical man let him do it in his own plain, everyday way. It is wonderful how soon the readers of a paper begin to notice anything out of the common run about a prominent card. They soon discover that the writer seems to know what he is talking about, and are struck and attracted by his peculiar way of talking it. And who can there be better able to tell about a machine than he who has fathered it and nursed it and laid awake o' nights with it. Have you ever had an inventor call on you?

The public are quick to discover and appreciate freshness in the way of putting things. There is a certain vigor and force about the utterances of a thoughtful, though unlearned man, that the cultured man does not have; and while I have never yet seen it tried, I verily believe that if a sincere man could be brought to tell about his machine and kill the grammar and misspell his words in his own natural way, it would make a great hit. The public would soon discover that it was genuine, and the faults of language would detract none from the machine, because all who have to do with machinery well know that many of the best mechanical devices are originated and perfected by men who can handle tools better than the English language.

The writer has had some experience in advertising several machines, and has been considered successful in having his cards always read as they appear in each issue of the respective trade papers. His cards are perfectly artless. They are never twice the same, and they are written just as they occur to him at odd moments of the day they must be sent to the paper. They are never rewritten except for the sake of the compositor who must set them up in type. He says in his cards just what he would and does say to the caller at the shop, and in exactly the same way. Indeed, his best ones are generally the transcripts of actual conversations. He takes no pains with his grammar, syntax or anything else; never thinks about it any more than we think about such things when we talk to one another. As a consequence his cards attract attention. It is a great novelty to read things as people talk them. Nobody writes as people talk save the best writers of dialect stories. The great army of story writers who pretend to portray contemporary American life all make a failure of it because none yet have dared to write as Americans talk in their daily life and intercourse with one another. The writer stumbled into putting down on paper what is every day said, and everybody reads it, and he awakes one fine morning to find himself, much to his surprise, known as a clever advertisement writer, and the editors of this paper think it worth while to give up all this valuable space to him that he may tell his fellow machinery makers how to do it!

Time was, however, when he did not write his advertisements this way, and the results were very disappointing. Like you and hundreds of others he blamed the whole failure upon the trade paper, questioned in his mind their claim of circulation, and kind of looked upon them as leeches fastened upon a patient and long suffering manufacturing public. To prepare his advertisement he would get out his pen and paper, and after painful wrestling and many trials and much polishing, he would succeed in getting one of the usual formal and stately advertisements written. Occasionally somebody happening to be in the market for a machine of the kind would send for a circular, as he would to all the other makers of such a machine.

The true function of the advertisement which produces results is to convince the regular reader of it that he never can be truly happy or satisfied until he has the very machine advertised. The good advertisement must have in a good measure that same indefinable something that the successful salesman or book agent has. The men we know who have strong individuality, influence us; so do advertisements. If your wife should tell you to bring her some hooks and eyes you would get the kind with a "hump." If soap for the "spare room" you know the kind you would buy.

How should a machine advertisement be written? Truthfully and naturally. Try writing one this way. At first you will be ashamed to print it over your name, because all these years you have been trained to read things that were not natural at all. To illustrate, suppose you have designed a new lathe with special reference to having it carry a heavy cut. You have tried it thoroughly and are fully persuaded it is a superior tool and you want orders for them. How would a card something like this strike you:

Slap it to Her. Don't be Afraid!

Cut of Lathe.

She's built to pull, that lathe is. Can't stall her. Not a tremble, either. Brown, old boy, you've got at last just what we machinists have long wanted. **A LATHE THAT CAN PULL** something when you have lots of stock to knock off. These banjo lathes make a fellow tired; and Brown, you're a public benefactor to bring out a lathe like that. A fellow can take a cut that is a cut on that lathe, and not be afraid of mashin' things. I wouldn't give that lathe for any two I ever saw. There's a big market for that tool.

A LATHE THAT CAN PULL. Keep your eye on it.

We have the usual literature. BROWN, JONES & CO.,
JONESVILLE, N. W

That's awful, isn't it? But is it not exactly the way it is talked in your shop? Do you ever see any lathe, drill-press or other machine-tool advertisements anything like that? Makes the shivers run down your back, doesn't it, simply to imagine such a card over your name. But suppose you were in the market for a lathe, and one "that can pull," you would look into Brown, Jones & Co.'s lathe, wouldn't you? Probably go and see it, and if it was what they represented, buy it. Besides, Brown will tell you about it in the same style week after week, and you'll read him every week, too; you can't help it. Another, like this:

Ha, Ha, Didn't We Tell You So!

Cut of Lathe.

The whole machine shop world wanted **A LATHE THAT COULD PULL SOMETHING.** Got tired of those weak-kneed kind. Well, we made it and here we are, night and day, making them, and people falling all over each other to get them. There's the Smith Mfg. Co., of Smithville, sent in an order for 12 the other day, and are jumping up and down yelling "Hurry, hurry !!! hurry !!!" because they are losing money every day they don't have them.

A LATHE THAT CAN PULL is what everybody wants, and here she is.

Usual circulars. BROWN, JONES & CO.,
JONESVILLE, N. W.

After several months following such advertisements you would in spite of yourself come to believe that Brown, Jones & Co. were making something especially good in the way of a lathe, and particularly a "puller." If any one should ask you to recommend a good lathe you would be sure to mention Brown's "puller."

But suppose Brown, Jones & Co. should make their announcements this way:

The Brown Lathe.

Cut of Lathe.

This lathe has been carefully designed so as to embody all the latest improvements in lathe construction. Our Mr. Brown, an expert in lathes, has added valuable improvements of his own with special reference to carrying heavy cuts. We believe this to be the best lathe now upon the market, and would invite all interested to call and examine for themselves.

Address for circulars and other information,
BROWN, JONES & CO.,
JONESVILLE, N. W.

Isn't that nice and dignified? But we doubt if it would have made any impression as you skimmed over the advertising pages. If you wanted a lathe "that can pull," you would hardly recognize it in this machine designed "with special reference to carrying heavy cuts."

In short, if you want your advertisements read by the same kind of men as you are yourself, talk in your cards the same way you talk in your shop and office, and in other people's shops and offices, and you will be listened to in your advertisements just as carefully as you are in your personal intercourse. Get on stilts and you are above all our heads.

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WE solicit communications from practical men on subjects pertaining to machinery, for which the necessary illustrations will be made at our expense.

ALL copy must reach us by the 10th of the month preceding publication.

Special Offers for April.

TO ANYONE sending us six NEW subscriptions to MACHINERY at $1.00 each, we wil send "Shop Kinks," by R. Grimshaw, a 400 page book which sells for $2.50. You want it

FOR ANYONE sending us five NEW subscriptions to MACHINERY at $1.00 each, we will haye a thorough preliminary examination made by a well-known attorney to ascertain the patentability of any device. The regular charge for this is $5.

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TO ANYONE sending us three NEW subscriptions and three dollars this month, we will send free one of the following books:

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THIS PAPER HAS THE LARGEST CIRCULATION OF ANY PUBLICATION IN THE MACHINERY TRADE.

APRIL, 1896.

WE have been thinking over some of the nice things that have been written and said to us during the past year and a half, and have come to the conclusion that our friends have only told us half the truth—and have refrained from any adverse criticism perhaps on account of our youthfulness, for fear of hurting our feelings.

But we are not thin skinned and haven't deluded ourselves with the idea that MACHINERY is perfect. We know better; know that it has faults (and we probably see some of them as clearly as anyone) and capabilities of improvement. We intend to improve it and want suggestions as to the best way of doing it. We don't intend making it a weekly, for the present at least, and we can't consider any plan for binding each issue in cloth and gilt—but any practical suggeston will be carefully considered and appreciated. We aim to make a practical paper for practical men in the machine shop, pattern shop, drawing room and engine room, and our columns reflect the ideas and experience of men who are engaged in these lines of work. Give us your idea of improvement and don't be backward in pointing out any defects you may find.

* * *

HONESTY IN THE SHOP.

The question of honesty in the shop is by no means confined to one side of the case, but it seems safe to say that as a rule, the honesty of the men depends in a great measure on their treatment. If, for example, the piece work system is introduced and the men find that any marked increase in production means a cut in piece price, they are not as apt to be strictly honest in all dealings with this firm, as they feel, and not without cause, that they have been unfairly treated. The manufacturers in this case do not look at the increased production from the same plant, but only see that the man is drawing more wages than formerly; consequently the workman acts accordingly and earns his money as easily as possible.

A special case which comes to mind is where the work was all done by the day and the men were particularly instructed to reject any casting which did not clean up perfectly in the bearings, as this was essential to the success of the machine. Here the workman did not lose the time which he had expended on the casting, but rather had the opportunity of gaining the good will of the employer, yet there were several instances where poor castings were not rejected, and the employers reputation endangered thereby, through carelessness or other unwarranted negligence.

This is the other extreme, but it shows what a large bearing the personal factor has on the question of shop production, in spite of the refinements of modern machinery which seem at times to almost replace human intelligence, but which in reality only concentrate the responsibilty in fewer hands—or heads.

A thorough system of inspection places the question of honest employees in fewer hands; but, as before stated, we have faith enough in human nature to believe that as a rule, employees will respond to honest treatment by giving honest service.

* * *

We wish to call attention to the articles on Labor's Value commenced in another column by Mr. W. S. Rogers, whose experience in this line, covers several good-sized shops, and whose conclusions seem to be reasonable from either side of the question. In a later paper he will show how, in his case at least, the cost of production decreased as the workmen's wages advanced, showing conclusively that higher priced men are the more economical when the system in vogue allows them to do rapid work without fear of a cut in rates. Those who have had experience with piece work know too well the failure to recognize the workman's right to a portion of the profits due to increased production.

PRACTICAL TALKS ON MECHANICAL DRAWING.—(5).

LOUIS ROULLION.

With the March issue the work in the elementary principles of mechanical drawing was completed. This month a series of drawings of standard screws, bolts and nuts is presented.

SHEET XVI.

SCREW THREADS.

In Fig. 21, let A B C D represent a cylinder, and the base line, D D, of the triangle be equal to the circumference of the cylinder. Imagine the side B D of the triangle placed against the element

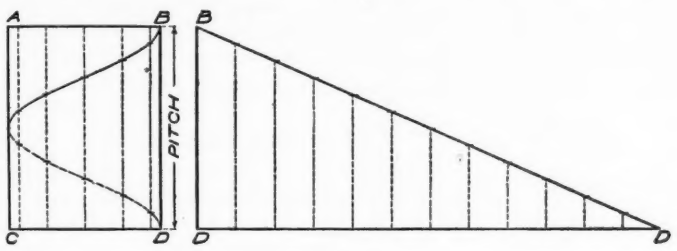


FIG. 21.

B D of the cylinder, and the triangle wrapped around the cylinder. The hypotenuse of the triangle would then present the appearance shown by the curve. Such a curve is called a *helix*, and the distance between B and D is known as its *pitch*.

Another way of imagining a helix to be traced is by a point rotating about a center and at the same time advancing in a straight line. This is clearly shown on a screw-cutting lathe in which the metal to be cut revolves with a uniform velocity and the tool is fed along a straight line parallel to the axis of the screw. When the tool is brought in contact with the metal a helix is cut upon the surface. A consideration of this process suggests a method of drafting a screw thread. In Fig. 22 the left-hand circle represents the end view of a bolt, the projection of which is shown directly beneath. Draw the circle and project the sides of the bolt. Along one of these sides lay off the pitch and repeat it for as many threads as may be required. The sides of a V-thread make with each other an angle of 60 degrees. Therefore draw the sides of the threads making angles of 60 degrees. Notice that in a single-threaded screw the point on one side is directly opposite the root on the other. Having the sides drawn, the next step is to find the curves that join them.

Divide the circle into any number of equal parts and divide the pitch into the same number of equal parts, say twelve. Then while the circle makes one complete revolution from A around to A again, the cutting tool would advance the pitch distance. When the circle has made one-twelfth of a revolution, or from A to B, the tool will have advanced one-twelfth of the pitch. Therefore if the point B be projected to the second line of division of the pitch, a point on the curve it obtained. Let the circle revolve through another twelfth of a revolution, or to the point C, and at the same time let the tool advance another twelfth of the pitch. The result of these combined movements may be shown by projecting the point C to the third line of division of the pitch, thus determining another point on the curve. Continue this process of projecting each point of division of the circle in succession to the corresponding lines of division of the pitch. Join the points thus determined by a smooth curve. It will be sufficient to draw but one-half the curve, as the rear half is hidden from view. The curve may be traced upon a piece of tracing paper and repeated as many times as desired. This is done by placing the ends of the curve over each pair of points that are to be connected and then going over the curve with a pencil, pressed somewhat heavily. An impression of the curve remains upon the sheet, which may then be inked in. Or instead of using a pencil, a number of points may be pricked through the curve, and then joined.

The curve representing the bottom of the thread is obtained by a method similar to that used in finding the curve of the top of the thread. In the top view draw a circle concentric to the one already drawn, and having a diameter equal to the thickness of the bolt at the root of the thread. This curve is divided by radial lines from the points of division of the outer circle. The remainder of the process is identical with that just described.

A desirable and ready method of drawing the two curves is shown in Fig. 23. Upon a piece of stiff cardboard or thin wood draw the curves in the manner explained above. The letters of Fig. 23 correspond with those of Fig. 22. Trim the cardboard or wood, leaving a smooth edge along the curve. Use this as a template with which to draw the curves.

In a square-threaded screw the depth and width of the thread each equals one-half the pitch. To draw the square-threaded screw shown in Fig. 22, lay off the pitch along the sides and sketch in lightly the squares representing the depth and width. The curves are obtained as in the case of the V-thread. Observe what parts of the curves are hidden, and draw only such parts as appear in the front view.

The profiles at the right in Fig. 22 show the standard threads. The upper one is that known as the Sellers' or U. S. Standard Screw Thread, the center one is the Whitworth or English Standard, and the lower one is the Standard Square Thread.

The angle of the Sellers' thread is 60 degrees. One-eighth of the top is taken off and added to the bottom, thus doing away with the sharp corners. The angle of the Whitworth thread is 55 degrees. One-sixth of the top is taken off and added to the bottom. The top and bottom of the thread is rounded. The proportions of the square threaded screw were given above, and are also shown on the drawing.

Screws are generally right-handed, although at times it is necessary to have a left-handed screw. A right-handed screw is one that when turned in the direction of the hands of a clock will enter the material into which it is being screwed. Screws are also single, double and triple threaded. In a single-threaded screw, the thread after one revolution, is directly below and next to where it started from. In a double-threaded screw, two screw threads may be imagined as wrapped about the bolt side by side. The pitch of the double-threaded screw is measured from a point in one thread to the corresponding point in the same thread after making a complete revolution. In drafting a double-threaded screw lay out each thread by itself, and as though a single thread of half the depth.

It is customary to speak of pitch as the number of threads per inch, rather than by the true pitch measurement. A thread of one-eighth inch pitch is known as "8-pitch;" that is, there are eighth threads to the inch. The following is a table that the draftsman and machinist should be familiar with:

SELLERS' OR U. S. STANDARD SCREW THREADS.

Diam.	Pitch.	Diam.	Pitch.	Diam.	Pitch.	Diam.	Pitch.
¼	20	13-16	10	1½	6	2½	4
5-16	18	⅞	9	1⅝	5½	2¾	4
⅜	16	15-16	9	1¾	5	2 13-16	3½
7-16	14	1	8	1⅞	5	3	3½
½	13	1 1-16	7	1 15-16	5	3¼	3½
9-16	12	1⅛	7	2	4½	3 5-16	3¼
⅝	11	1¼	7	2¼	4½	3½	3¼
11-16	11	1 5-16	6	2 5-16	4½	3¾	3
¾	10	1⅜	6	2⅜	4	4	3

The screws shown in the drawings are not drawn to these

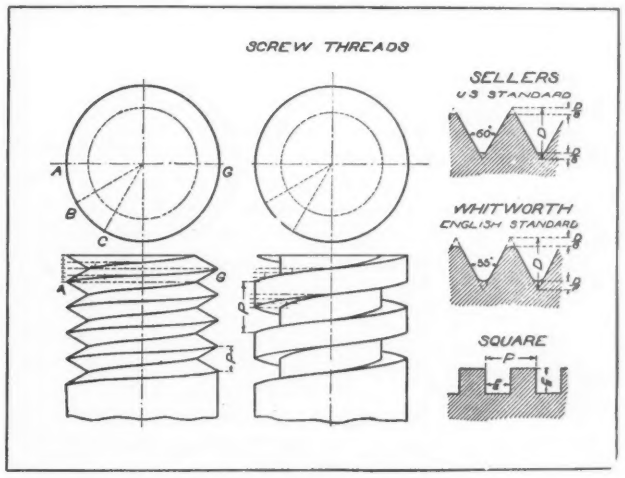


FIG. 22.

standards, as the thread would be too sharp to show clearly the method of obtaining the curve.

SHEET XVII.

CONVENTIONAL SCREW THREADS.

The method of representing screw threads shown in Fig. 24 is not used in working drawings because of the amount of time and trouble it necessitates, and because the object of the drawing can be attained as well as by a much simpler method. The usual

way of showing small screw threading is shown at the upper left-hand side of Fig. 24. The longer lines represent the tops of the threads and are drawn about one-eighth of an inch apart, regardless of what the pitch may be. The shorter lines, for the bottom of the threads, are drawn slightly heavier and not quite to the sides of the thread. Some shops use a modification of this scheme, in which the shorter and heavier lines extend from one of the sides to the center line. The method shown at the right is also in

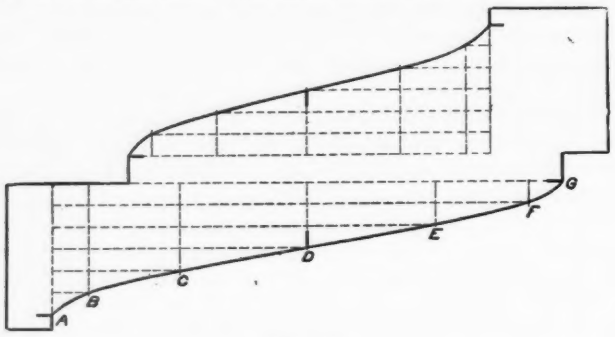


FIG. 23.

use, and is commendable for its simplicity. When screw threading is shown in either of these ways the pitch must be given in an accompanying note.

The lower center drawing is the square screw thread of Fig. 22, in which straight lines are substituted for the curves. At the left is shown another and simpler method of showing the same square thread. At the right, the curves of the V-thread of Fig. 22 are shown as straight lines.

SHEET XVIII.

STANDARD BOLTS AND NUTS.

This sheet is designed to show the proportions of standard bolts and nuts. The diameter of the bolt is the unit from which the various proportions are derived. In Fig. 25, take the diameter of each of the bolts as one inch. The lengths of the bolts are here shown as indefinite. To draw the champfer on the hexagonal nut or head, take a radius equal to the thickness of the nut and with center at the intersection of the center line and bottom of nut, describe an arc. Where the arc intersects the sides of the front face determines the extremities of the two side arcs. By trial find a point on the center line of the side face for an arc passing through the top of the nut and the two extremities before determined. The point is about one-quarter way down the center line. The champfer on the square nut is here shown as equal to that of the hexagonal nut. The two bolts and nuts are to be finished to standard proportions as given in the table.

A hexagonal nut may be drawn with close approximation to accuracy by the following method, which dispenses with the draw-

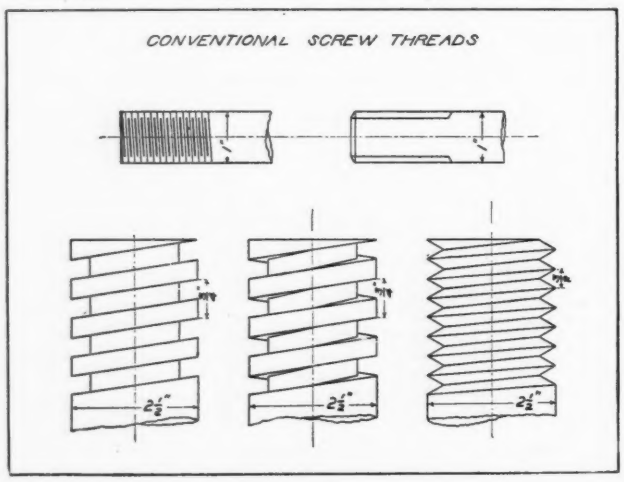


FIG. 24.

ing of the hexagon. First draw the center line of the nut, and then the top and bottom lines equal to the diameter of the bolt. Draw the front face slightly narrower than the diameter, and take the width of each of the side faces as equal to one-half the front face. Add the champfer as above. Three faces of an hexagonal nut should always be shown, and but one face of a square nut.

SHEET XIX.

SPRINGS.

This sheet shows conventional methods of representing springs. The spring at the left of the sheet may be considered a square-thread screw from which the bolt has been removed. The curves, except at the ends, are shown as straight lines. The two springs at the right are of round wire, sections of which are shown. Draw circular arcs an inch apart for the larger spring and three-eighths for the smaller one. Draw lines tangent to these arcs as shown in Fig. 26.

EXERCISES.

EXERCISE 16.—TRUE SCREW THREADS.

Draw three inches of screw threading on a two and one-half

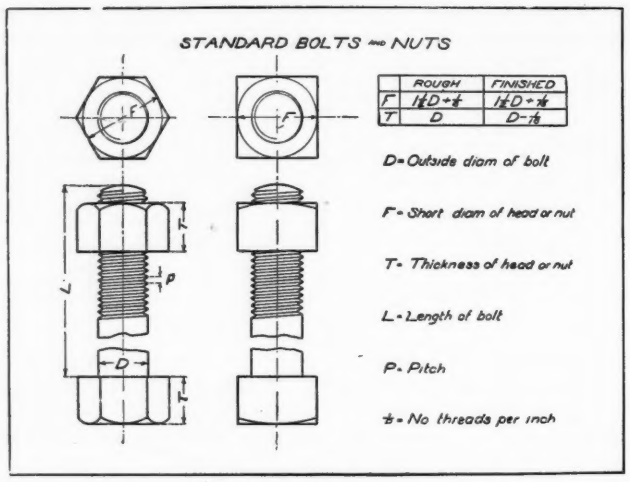


FIG. 25.

inch bolt. Let the thread be the U. S. standard. Find the pitch from the table given on page 235.

Draw a double-threaded square screw; diameter 2½ inches; pitch 1 inch.

Draw a sectional view of the nut for the square screw thread.

EXERCISE 17.—CONVENTIONAL SCREW THREADS.

Substitute for the three lower screws of Fig. 24 double-threaded screws of the same kind. Let the pitch of the square threads be one-half inch. For the V-thread take standard pitch. In the upper left-hand screw, show the bottom threads as heavy lines extending from one side to the center line. Place the screw in the upper center of the sheet.

EXERCISE 18.—STANDARD BOLTS AND NUTS.

For the two bolts and nuts of Fig. 25 substitute similar ones of

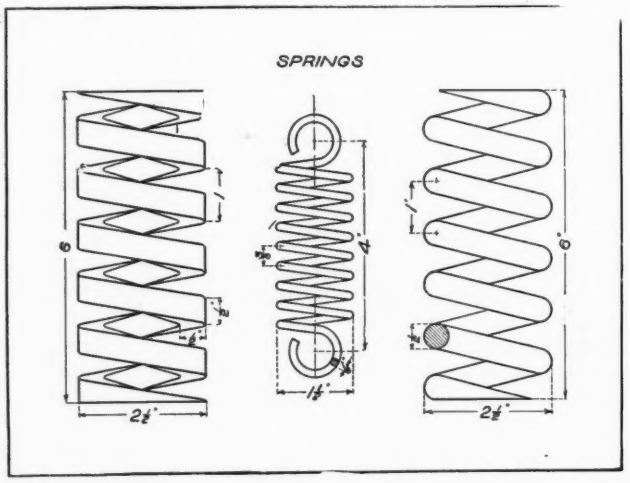


FIG. 26.

1¾ inches diameter of bolt. Lay lengthwise of sheet and draw without the top views of the nuts, by the method explained above. Put on all dimensions shown by letters in Fig. 25.

EXERCISE 19.—SPRINGS.

Fig. 26 may be varied by closing the springs until the spaces are but three-quarters of the distances given. Take other dimensions the same.

* * *

SOME men seem to have the idea that iron or steel is perfectly solid and rigid and in fact can stand almost any abuse from hammering or prying. In reality a heavy steel rifle-barrel will deflect of its own weight if supported only at the ends, and the same can be said of heavy cast iron beams.

SYSTEMATIC MACHINE DESIGNING.—2.

H. M. Norris.

7. *Internal Gear Pinion.*—The internal gear pinion C, to give a uniform velocity, to have sufficient strength, and to cause as little wear as possible, should have not less than twelve teeth.

8. *Face Gear.*—The face gear E must be of suitable pitch and face to stand the pressure of 13 768 pounds, which will come upon the teeth of the internal gear, multiplied by the lever arms of the internal gear and face gear (Fig. 5) plus the power necessary to overcome the friction of the cone shaft.

The lever arm of the internal gear pinion is 4.8 inches. The lever arm of the face gear, since its center lies in the same center as the internal gear pinion, and must be small enough in diameter to clear the spindle, is limited as shown in Fig. 6. The internal gear and its pinion have 68 and 12 teeth respectively and are of 2.5133 inches circumferential pitch. The spindle is 12 inches in diameter. Hence

$$2\,[27.2-(4.8+6)]=32.8 \text{ inches}$$

is the outside diameter of the largest gear that can possibly be used. The pitch of this gear can be somewhat finer than that of the internal gear; let us assume it at 2 inches diametral pitch, which gives us 63 teeth as the greatest number that the gear can have, then our lever arm is

$$\tfrac{1}{2}(\tfrac{63}{2})=15.75 \text{ inches.}$$

With 4.8 inches and 15.75 inches as the lengths of our lever arms (Fig. 5) and the force of 13 768 pounds acting upon the end

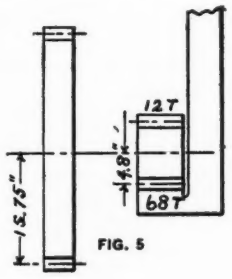


FIG. 5

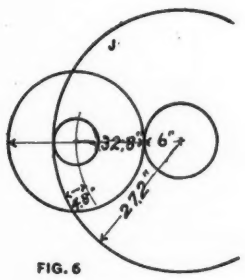


FIG. 6

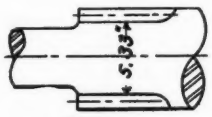


FIG. 8

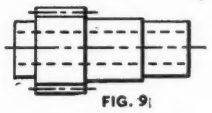


FIG. 9

of the short arm in the direction indicated by the arrow (Fig. 7), also providing that there were no friction and that the several parts forming the lever were without weight, we would have—

$$\frac{13\,768\times 4.8}{15.75}=4196 \text{ pounds}$$

as the power that must be applied upon the end of the long arm to balance the load upon the short arm. Then

$$13\,768-4\,196=9\,572 \text{ pounds}$$

is the pressure upon the fulcrum A, Fig. 7. Assuming the weight of the shaft, gear and cone at 600 pounds and adding this weight to the pressure caused by the leverage just found, we have—

$$9\,572+600=10\,172 \text{ pounds}$$

as the whole pressure upon the cone-shaft journal-boxes. Hence the friction is—

$$10\,172\times .08=814 \text{ pounds.}$$

9. *Cone Shaft Journals.*—Before we can determine the whole strain upon the teeth of the face gear, we must decide upon the approximate diameters of the cone-shaft journals. The shaft cannot have a large diameter on account of passing through the cone pinion, so it must be made of steel. The large journal, however, must have sufficient diameter to resist the torsional stress due to transmitting power from the face gear to the internal gear. The formula for the ultimate torsional strength of round steel shafts is—

$$\frac{.2\,d^3\,S}{R}=W \quad (1)$$

where S = ultimate shearing strength, W = moment of load, R = radius through which the load is applied, and d = diameter of shaft. By transposing we have:

$$\sqrt[3]{\frac{R\,W}{.2\,S}}=d \quad (2)$$

Taking the safe torsional strength of steel at 4 500 pounds per square inch and substituting our known values, gives us:

$$\sqrt[3]{\frac{48\times 13\,850}{.2\times 4\,500}}=d$$

$$\sqrt[3]{73.86}=d$$

$$4.19=d$$

which for extra stiffness we will increase to 5 inches. The small journal of the cone shaft has no great strain upon it; so let us assume its diameter at 4 inches, which gives us 4.5 inches as the mean radii of the journals.

10. *Face Gear* (continued).—The friction of the cone shaft, multiplied by the mean radii of its journals, and divided by the radius of the pitch circle of the face gear, will give us the additional strain upon the teeth of the gear, due to friction, or

$$\frac{814\times 4.5}{15.75}=232 \text{ pounds.}$$

Hence the whole strain upon the tooth of the face gear is—

$$4\,196+232=4\,428 \text{ pounds.}$$

To determine what pitch is most suitable for this strain, let us assume the face of the gear at 4 inches and allow for a speed of 200 revolutions per minute. Then, proceeding in the same manner as we did in the case of the internal gear, section 6, where

$$p=\frac{W}{S f y}$$

we have—

$$p=\frac{4\,428}{6\,000\times 4\times .138}=1.36 \text{ inches.}$$

as the circumferential pitch of the gear.

By table III. we find that 1.3963 inches is the nearest larger pitch than 1.36 inches; so let us take it as the pitch of the face gear.

With the outside diameter of the gear limited at 32.8 inches, as we found in section 8, and with 1.3963 inches as the circumferential pitch, we could have 71 teeth in the face gear. But for appearance it would be better to have the outside diameter of the gear a little smaller than the diameter of the cone flange, next to which it goes. Giving the gear 70 teeth will allow the flange to project .25 inch above the face of the gear, clear the spindle by ⅛ inch and be 32.5 inches in diameter.

11. *Face Gear Pinion and Diameter Back Gear Shaft.*—The face gear pinion will have 1.3963 inches circumferential pitch, 4 inch face, and must transmit 4 428 pounds to the face gear; this much we have determined. The pinion, Fig. 8, on account of being cut upon the back gear shaft, must have enough teeth to allow it a sufficiently large diameter at the root of the teeth. With 14 teeth we have a diameter of 5.33 inches and a lever arm of 3.11 inches. Taking the safe torsional strength of the shaft at 4 500 pounds per square inch and substituting our known quantities in equation 2, section 9, we have—

$$d=\sqrt[3]{\frac{3.11\times 4\,428}{.2\times 4\,500}}$$

$$d=2.5 \text{ inches nearly}$$

as the diameter of a shaft which would be strong enough to transmit the necessary power providing that the length of the shaft did not greatly exceed its diameter. But as it will be from 5 to 6 feet in length and will need to have great stiffness, we will increase this diameter to as much as 4.5 inches, which will allow about ⅛ inch clearance between it and the cone flange.

12. *Cone Pinion and Back Gear.*—The cone pinion J, since it fits over, and runs upon, the cone shaft, must have enough teeth of suitable pitch to give it a thickness of metal between the root of the teeth and the shaft (Fig. 9), such that the sleeve at the right of the teeth can be reduced in diameter to an amount sufficient for the teeth of the back gear to clear the sleeve when the gear is slid out of mesh with the pinion; and also for again reducing that diameter where the pinion is keyed to the cone.

In the latter part of section 9 we assumed the diameter of the cone shaft at its small end at 4 inches. Let us make its diameter under the pinion 4.25 inches. Then, assuming a pitch of 3 inches for the pinion and that it will require a thickness of 2 inches beneath the teeth, we find that we must have a pitch circle 9 inches in diameter, which gives us 27 teeth and a lever arm of 4.5 inches.

The pitch circle of the back gear must be of such a diameter that the center distance of the back gear and cone pinion will

equal the center distance of the face gear and face gear pinion The center distance of the face gear and its pinion is—

$$\frac{70+14}{2} \div \frac{3.1416}{1.3963} = 18.666 \text{ inches}$$

With 4.5 inches as the radius of the cone pinion we then have

$$18.666 - 4.5 = 14.166 \text{ inches}$$

as the radius of the back gear.

With 14.166 inches and 3.11 inches as the lengths of the lever arms in the back gear and face gear pinion respectively (Fig. 10) and the force of 4 428 pounds acting upon the end of the short arm in the direction indicated by the arrow (Fig. 11); also providing that there were no friction and that the several parts forming the lever were without weight, we would have—

$$\frac{4\,428 \times 3.11}{14.166} = 901 \text{ pounds}$$

as the power that must be applied upon the end of the long arm. Then

$$4\,428 - 901 = 3\,527 \text{ pounds}$$

is the pressure upon the fulcrum A. Assuming the weight of the gear and shaft at 400 pounds and adding it to the pressure just found caused by the leverage, we have

$$3\,527 + 400 = 3\,927 \text{ pounds}$$

as the whole pressure upon the shaft journals. Hence the friction is

$$3\,927 \times .08 = 314 \text{ pounds.}$$

The diameter of the journal at the right end of the shaft will be the outside diameter of the face-gear pinion, or 7.111 inches. The journal at the left end of the shaft should have a diameter such that it will allow for a shoulder on either side of the gear—assume it at 4 inches. Then the mean radii of the journals is 2.78 inches, which, if multiplied by the friction and divided by the radius of the pitch circle of the back gear, will give us the additional strain upon the teeth of the back gear and cone pinion due to friction, or

$$\frac{314 \times 2.78}{14.166} = 61 \text{ pounds about.}$$

Hence the whole strain upon the teeth of the gear and pinion is—

$$901 + 61 = 962 \text{ pounds.}$$

To determine what pitch is most suitable for this strain, let us assume the face of the gear and pinion at 3 inches and then proceed in the same manner as we did in the case of the internal gear and face gear. The cone pinion, since it runs upon a steel shaft, had better be made of cast iron; so we will consider its teeth rather than those of the back gear, as it will be the weaker of the two. Let us assume, as before, that the pinion will have 27 teeth and that it will at times run at 600 revolutions per minute. Referring to Mr. Lewis' tables and formula, we have S = 4 000 pounds, $y = .111$ and

$$p = \frac{962}{4\,000 \times 3 \times .111} = .722 \text{ inches.}$$

By table III. we find that 1.0472 inches is the nearest larger pitch than .722 inches that will give us a center distance between the back gear and cone pinion equal to the center distance of the face gear and the face-gear pinion which fixes the number of teeth at 85.

13. *Diameter of Largest Cone Step.*—The diameter of the largest step of the cone depends upon the diameter of the cone's flange, inasmuch as it must be enough smaller than the flange to prevent the belt from climbing up onto the face of the face gear. The flange, which we have previously decided to make 32.5 inches in diameter, should project about 1 inch or 1.5 inch above the step. Hence 30 inches is the largest diameter, in even inches, that the cone can have. This gives us 15 inches as the length of lever arm.

14. *Width of Belt.*—In section 12 we determined the length of the lever arm of the cone pinion at 4.5 inches and found that there would be a force of 962 pounds acting upon its end in the direction indicated by the arrow, Fig. 13.

Providing that there was no friction and that the parts forming the lever (Fig. 14) were without weight, we would have

$$\frac{962 \times 4.5}{15} = 288 \text{ pounds}$$

as the power that must be applied upon the end of the long arm. Then

$$962 + 288 = 1\,250 \text{ pounds}$$

is the pressure upon the fulcrum A, Fig. 13. If we assume that the lift of a double belt, due to its tension and friction, is equal to 111 pounds per inch of width, that the belt will be 5½ inches wide, and that the cone and its pinion will weigh 300 pounds, we have

$$(111 \times 5\tfrac{1}{2}) - 300 = 311 \text{ pounds nearly}$$

as the additional load upon the fulcrum. Adding this load to the pressure caused by the leverage, gives us—

$$1\,250 + 311 = 1\,561 \text{ pounds}$$

as the whole pressure upon the cone's bearings. Hence the friction is

$$1\,561 \times .08 = 125 \text{ pounds nearly.}$$

In sections 9 and 12 we made the diameters of the cone-shaft journals 5 inches and 4.25 inches respectively. So the mean radii of the cone bearings is 4.625 inches, which, multiplied by the friction and divided by the radius of the largest cone step, will give us the additional power that must be applied to the face of the cone to counteract the power consumed in friction, or

$$\frac{125 \times 4.625}{15} = 38 \text{ pounds about.}$$

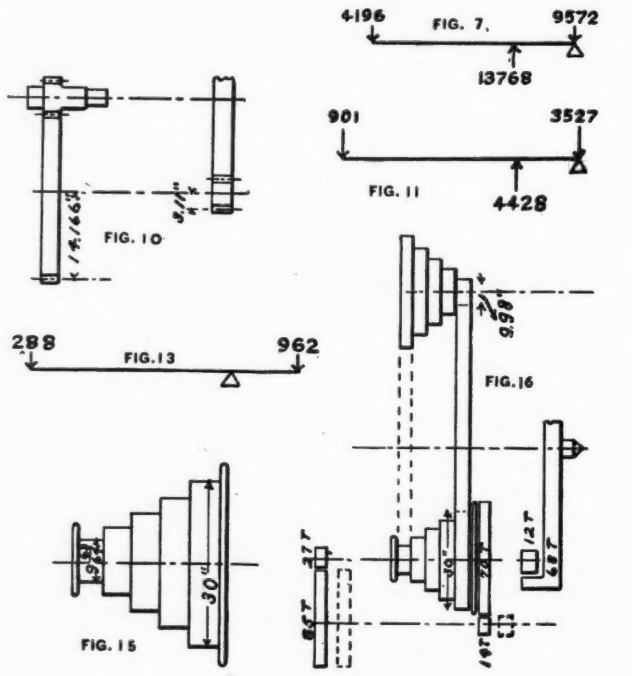
Hence the whole power that must be applied to the face of the largest cone step to make the lathe capable of taking the cut of ¾ × 1 inch is—

$$288 + 38 = 326 \text{ pounds.}$$

The mean effective pulling power of a double belt, as deducted by J. H. Cooper from all the belting rules established by the best authorities, is 65 pounds per inch of width. Therefore the faces of the cone's steps must be

$$326 \div 65 = 5 \text{ inches}$$

in width, which, that the lathe may have sufficient power to meet any sudden load put upon it, let us increase to 5.5 inches.



15. *Diameter of Smallest Step.*—The smallest step of the cone must be of such a diameter that the ratio of increase in the rate of rotation per minute of the spindle caused by shifting the belt from any step to the next larger one when the back gears are thrown out of mesh will be the same as the ratio of decrease in speed caused by shifting the belt from the largest step with the back gears out of mesh to the smallest step with the back gears in mesh. In other words the rate of decrease of each of the ten speeds must be in arithmetical progression.

If D = diameter of largest step, d = diameter of smallest step, R = ratio of the back gears, and s = number of cone steps. Then

$$d^2 = \frac{D^2}{(R)^{\frac{s-1}{s}}}$$

The diameter of our largest step = 30 inches, the number of cone steps = 5 and the ratio of the back gears =

$$\frac{27}{85} \times \frac{14}{70} = \frac{1}{15.66}$$

Hence by substitution,

$$d^3 = \frac{900}{\left(\sqrt[5]{15.66}\right)^4}$$

$$d^3 = 99.62$$

$$d = 9.98 \text{ inches,}$$

which is the diameter of the smallest step.

16. *Diameters of the Intermediate Cone Steps.*—Unless it is necessary that the cone on the countershaft should be larger or smaller in diameter than the cone in the headstock so as to give a greater or less velocity ratio between the cones than can be obtained from the pulleys on the main-line shafting and the countershaft, it will obviously be an advantage to have the relative steps of each cone of equal diameter so that they may be cast from the same pattern. By making use of Nystrom's formula for cone pulleys, page 404 of his Hand Book, we can make the diameters of the intermediate steps of the headstock cone such that one pattern will answer for both or so that the headstock cone will work equally as well with a larger or smaller one on the countershaft. If

R=radius of the largest cone step.
r=radius of the smallest cone step.
a=distance in inches between cone centers.
D=diameter of middle step.
R′=radius of middle step.
d'=diameter of step next to largest.
d=diameter of step next to smallest.

Then

$$D = R + r + \frac{(R-r)^2}{\pi a} \quad (1)$$

$$d' = R + R' + \frac{(R-R')^2}{\pi a} \quad (2)$$

$$d = R' + r + \frac{(R'-r)^2}{\pi a} \quad (3)$$

(a, or the distance between cone centers, is usually taken at 8 feet.)

Having determined the diameters of the largest and smallest steps of our cone (Fig. 15), we can find the diameter of the middle step by substituting the values of R and r in equation I, which gives us

$$D = 15 + 4.99 + \frac{(15-4.99)^2}{3.1416 \times 96}$$

$$= 20.322 = 20\tfrac{21}{64} \text{ inches.}$$

Substituting the value of R and R′ in equation 2, we have

$$d' = 15 + 10.16 + \frac{(15-10.16)^2}{3.1416 \times 96}$$

$$= 25.237 = 25\tfrac{15}{64} \text{ inches}$$

as the diameter of the next largest step. Substituting the values of R′ and r in equation 3, we have

$$d = 10.16 + 4.99 + \frac{(10.16-4.99)^2}{3.1416 \times 96}$$

$$= 15.235 = 15\tfrac{15}{64} \text{ inches}$$

as the diameter of the next smallest step.

17. *Speeds for Running.*—The slowest speed at which the lathe will be required to run will be a speed suitable for turning the periphery of the largest cast iron cylinder that will swing over the tracks. Cast iron rarely requires to be turned at a slower speed than 12 feet per minute. The greatest capacity of the lathe is a cylinder of 60 inches diameter. The circumference of a 60 inch cylinder is

$$60 \times 3.1416 = 188.5 \text{ inches, or } 15.7 \text{ feet.}$$

Hence

$$12 \div 15.7 = .76$$

is the number of turns per minute of lathe spindle that we must have to give a cutting speed of 12 feet.

The fastest speed at which the lathe will be required to run will be a speed suitable for smoothing-up small work with file or emery cloth. One hundred and fifty feet per minute is fast enough for a lathe of this size. Considering that there will be but little work less than 6 inches diameter, we have

$$\frac{150}{.5 \times 3.1416} = 95 \text{ revolutions}$$

as the maximum speed of the lathe.

18. *Speed of Countershaft.*—Having determined the slowest and fastest speeds of the lathe spindle at .76 and 95 revolutions per minute, let us find how many revolutions per minute will be required of the countershaft to give these speeds if we use the same size cone as in the headstock. It is obvious that the lathe will run at its slowest speed when the belt and back gears occupy the positions shown in Fig. 16, and at its fastest speed when the belt and back gears are in the positions indicated by the dotted lines. When the lathe is running at its slowest speed the ratio between the countershaft and lathe spindle is

$$\frac{30}{9.98} \times \frac{85}{27} \times \frac{70}{14} \times \frac{68}{12} = 267$$

Hence

$$267 \times .76 = 203$$

is the number of revolutions per minute that the countershaft must make to revolve the spindle .76 of a revolution per minute.

When the lathe is running at its fastest speed, the ratio between the countershaft and lathe spindle is

$$\frac{9.98}{30} \times \frac{68}{12} = 1.88$$

Hence

$$1.88 \times 95 = 179$$

is the number of revolutions per minute that the countershaft must make to transmit a speed of 95 revolutions per minute to the spindle.

With these figures we see that the countershaft is required to run faster when the lathe is working at its slowest speed than when at its fastest, and vice versa. But by fixing the speed of the countershaft at 191 revolutions per minute, the mean of the two just determined, we shall have a greater range of speed both ways; *i. e.*, the lathe will run faster that 95 and slower than .76.

* * *

MACHINISTS' PIECE WORK.

W. H. CHAPPEL.

What is the reason that good machinists are so scarce—machinists who can go right ahead and turn out good work, without fooling around half a day to do what ought to be done in half an hour? It actually seems as though good machinists were becoming extinct.

I have heard and read many times over, the complaint that a good man can no longer get a job, because all the shops were filled with hoboes, chumps and monkey-wrench machinists; and I know it to be a fact that it is a case of filling the shop with them or going without men altogether. It is actually impossible to get anything else.

I want to relate a little instance right here of a man who came into the shop a few days ago, hired out as a first-class vise hand, twelve years' experience. First job given him was a gear to chip key-seat in. After looking over the files and chisels given him, borrowing a hammer from the man next to him, he began to size up the job for a few minutes, then walked over to the foreman and says: "Well, boss, can't you give me something else? Don't believe I want to tackle that job." He got something else all right, and got it sudden; then had the nerve to pull out a letter of recommendation and shove it under the foreman's nose, to prove his high class ability.

Another one, a lathe hand, had had ten years' experience on lathes; asked particularly about the wages paid; settled that he was to get two-fifty if satisfactory. Started on an 18-inch lathe boring wheels, gears. etc.; had twelve collars similar to a solid set collar for a $2\frac{7}{16}$ inch shaft to bore and face one side; chuck was all right, lathe and tools O. K. and suitable for this work; yet this man consumed *nine hours* boring twelve of these collars. Foreman said to him: "Is that the best you can do? We can't stand *that* price; that's about 19 cents apiece for those collars. We have an apprentice boy who can bore twelve of them in two or three hours." "Well," says the new man, "this is the first time in my experience that anyone found fault with *my* day's work. Guess you are one of those foremen that no one can suit. Just give me my time."

If you advertised for first-class machinists to-morrow, you wouldn't get two out of twenty who knew enough to grind a flat drill, no matter what price you are willing to pay. Why is it? Some are accurate, but so slow you can't keep them at any price; some slow because the Lord made them that way; others slow because afraid of doing more than they get paid for. Some are so almighty swift they can do a job three times over in no time, then you have to get some one else to do it in order to get it right. There isn't any exorbitant profit made off this kind of service either. Men who are valuable are those who have some judgment; know a rough job from a fine one; know when to stop

chipping and commence filing; know how to turn out work in a reasonable time. No one wants a man who hasn't more sense than to be trimming the rags off the edge of a piece of ⅜-inch boiler-plate for the top of a pig-iron truck, with a fine file, when there is a good coarse emery-wheel running near by; and no foreman delights in telling that same man the same thing a dozen times a week.

Whose fault is it that they know no better? Have they neglected their opportunities for improvement? Don't they care whether they ever learn the business or not? Have they no capacity—would they do better at anything else? There may be the same percentage of good machinists as ever, but I doubt it. Talk about hard times. The times are very hard in which to secure any first-class mechanics in the machinists' line. We read and hear the cry that the good mechanics are crowded out by the labor-saving machines and specialists; specialists made of farmers' sons who come into the city and learn the trade in ten minutes running some machine with a hopper into which they throw pig iron, and it comes out steam engines. Suppose this is the case; where are the mechanics who are being crowded out? We want to hire a few this week.

Mechanics, like poets, are *born*, not *made;* and as far as good, all around mechanics being crowded out by those of inferior ability is concerned, it is nonsense to think of it. We might as well think of Paderewski, who can get a hundred thousand dollars a month playing the piano, being crowded out by some bum who thumps a piano in a saloon for fifty cents a night.

There is a place for everybody, and everybody ought to be where they belong. Unfortunately they don't always get there. But it seems as though when a man is once into a business in which he is able to make a living with no prospects of anything better to change to, it is his duty to do the best he can—read up and exert himself to make some advancement.

Speaking of piece-work, are we not all working piece-work in a certain sense? Don't we have to give a customer a price before he will let the contract to us? Don't we have to keep within that price or go out of business and let the next man do it? Very well; we must either put the men on piece-work in the shop or see that they turn out a day's work in proportion to their day's pay. The only difference between day-work and piece-work is that with piece-work everything goes smooth; with day-work there is a constant friction; hiring men, discharging men; no assured costs; nothing to stand on.

A lathe hand comes along, hires out, wants so much a day; after a week's trial you find his work is costing you more than the last man's who ran the lathe. What are you going to do? You can tell him to *crowd* it a little. Suppose he is one of us fellows who *won't* crowd it when you ask him to. Suppose you tell him frankly what the other man did, and he gets his back up and tells you he won't kill himself for *anybody*, and quits; or suppose you have sized him up and know he is no good, and gave him his time without any comments or explanations. It all means friction and annoyance, no matter how you do it.

Now suppose your work is piece-work. You are paying ten cents each for pieces turned out of this lathe. One man tries it, makes a dollar and fifty cents a day by hard work; quits, can't stand that price. Another fellow comes along and makes three-fifty a day, and does it *easy*—no trick at all. Some other fellow in the shop offers to do them for less a piece; is satisfied if he don't make quite three-fifty, and so the price goes down and down, until it is so low that if the first man who quit because he couldn't make but one-fifty were to tackle the job *now*, he wouldn't make a *dollar a week* out of it. Yet the man who is at it now is making a fair day's pay. Why? Because he has a specialty he can handle, like the quack doctor who was h—l on fits.

There is nothing on earth in the line of necessities which will ever be made under such circumstances that *no one* can get a living out of it; and the idea that the *man* who *can* do a certain thing in a superior manner will ever be crowded out by a man who can't—well, mules are as liable to get jobs away from locomotives. Piece-work is the only thing which will put men in their proper places. Piece-work is the only thing which will ever pay men according to their ability.

* * *

THERE is a very useful kink in use in the shops of C. H. Bausch & Sons, of Holyoke, Mass., to inform the foundryman how much iron to melt for each large casting. As some of their castings weigh as much as 6,000 pounds, it is essential that the heat contain sufficient metal. The weight of the first casting is calculated approximately from the volume of the piece, then the actual weight of the casting is stamped on the pattern so that the amount of metal necessary can be seen at a glance. Should the pattern be altered or any material variation in weights occur, the latest weight is stamped on the pattern.

* * *

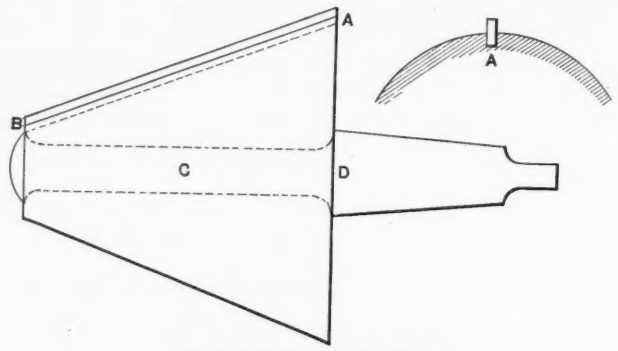
THERE are plenty of little leaks in any establishment that should be attended to before the salaries commence to suffer. It is often the old story of "A drop at the spigot, a quart at the bung."

* * *

MAKING EMERY WHEELS AND GRINDERS.

A visit to a progressive emery-wheel factory such as the Norton Emery Wheel Co., Worcester, Mass., with such a guide as Mr. E. W. Dodge, is both interesting and instructive, especially to those who imagine that "anything will grind," or have similar crude ideas regarding this branch of mechanics.

The wheels made by this company are mostly of the vitrified type, although in some cases the silicate wheel is made, particularly in the flexible wheels. The emery and other ingredients are stored above the mixing room, in bins having spouts which lead down to the mixing machines, where the correct proportions are measured out, according to the grade of wheel desired, and they are thoroughly mixed by the machines. The mixture is then drawn off into iron moulds and allowed to dry without pressure, in warm rooms (which are of course well supplied with racks), until the moisture is nearly dried out: this being called the first drying. They are then taken to the turning-off machines, which are very similar to a "potter's wheel," and as there may be some who are not familiar with this, it will be well to explain



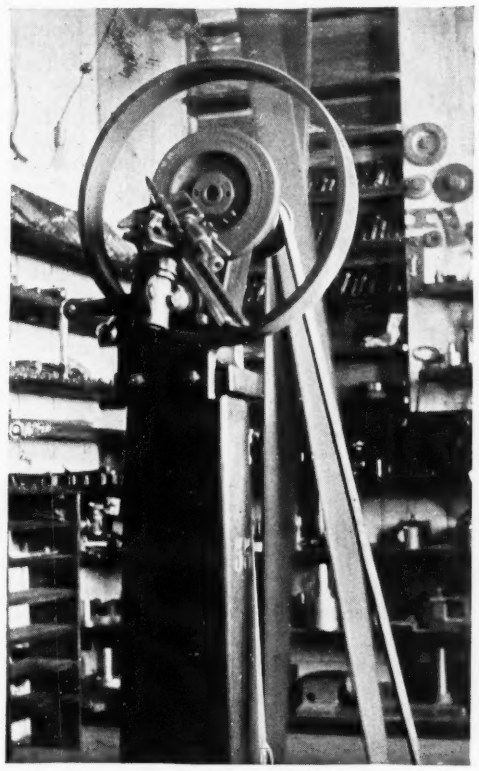
REVOLVING CONE OR PIPE CENTER.

that a potter's wheel is a flat disc of metal (usually), mounted on an upright shaft, so that the disc turns horizontally. Placing the lump of clay in the center of this, the potter revolves the wheel and shapes his wares. In this case the partially dried wheel is placed on the disk and the turner brings a tool down in a swinging frame until a stop is reached, then moves the tool towards the center of the wheel, truing the upper side and making the hole through the center. The wheel is then reversed and after being trued on that side, a metal ring is laid on, giving the size of the wheel, which is then turned off on the edge or face. From here it goes to the second drying room, and with it, as with every wheel of any size, a ticket telling its mixture, size, etc., and the man who turned it. After being sufficiently dried it is ready for the firing, and there are several large kilns for this purpose. These are packed full of wheels with a plentiful supply of sand or other material between them, and the fires started and heat increased until a temperature of about 2,800 degrees is reached. This is maintained for about fifty-four hours and the fires allowed to cool down gradually, the time between first starting of the fires and the cooling down sufficiently to open, being from 210 to 240 hours; in other words, the entire time in the oven being about ten days. By this process the binding material (or the portion which is not emery) is vitrified and made a cutting agent, although of course not equal to the emery.

Then they go to the finishing room, where the centers are leaded, the wheels trued on both side and face, and then tested for balance, so as to insure running well at high speed. In connection with truing wheels it may please (?) some of those who claim that nothing but a diamond will answer for truing emery wheels, to learn that chilled wheels or cutters are used almost exclusively, and that some of the harder grades of wheel will give

the diamond odds and beat it, the diamonds being softer than the wheels.

The testing room comes next, and the wheel, still shadowed by the ever-ready yellow ticket containing its pedigree, is placed on the testing spindle and the wheel started. The wheel is surrounded by a heavy wrought iron band of larger diameter than the largest wheel, and wide enough to catch the remnants of any wheel going to pieces during the test. The ring is backed by substantial planking and prevents damage to either building or attendant.



SAFETY RING ON GRINDER

In order to be positive that the wheels are tested properly, they have an accurate tachometer attached to spindle, and when the desired speed is reached, it is maintained for five minutes, giving the wheels every chance to go to pieces if there is any flaw or inherent defect, as will happen at times and escape detection by any other test.

The regular running speed recommended by this firm is 5 000 feet of rim speed per minute, and the wheels are tested at double this speed, or 10 000 feet per minute. As the strain imposed by centrifugal force varies as the *square* of the speed, this imposed *four* times the bursting strain they will ever be subjected to in practice if run according to the best modern practice or directions. The calculated strain at 5 000 feet per minute is 75 pounds per square inch, and when the wheels successfully withstand four times this, or 300 pounds, they are certainly tested far enough beyond the working strain to assure safety, having four as a "factor of safety."

It may be safely said of any make of wheel, that those bursting from any inherent fault are a small percentage of those which are broken by improper mounting, excessive speed or by allowing work to be jammed between rest and wheel.

The same yellow slip is still used, and after recording the test is sent to the office and each day the tests are sworn to before a justice of the peace. Then, when a complaint is made about a wheel which may have been broken or at least cracked in handling, there is a complete record of it from mixing to testing, which should satisfy anyone that the wheel has no inherent faults.

There is a very complete system of grading in use here, and it indicates clearly that it is much better to consult the makers before ordering, as by knowing what the wheel is supposed to do they can supply you with a wheel adapted for that work.

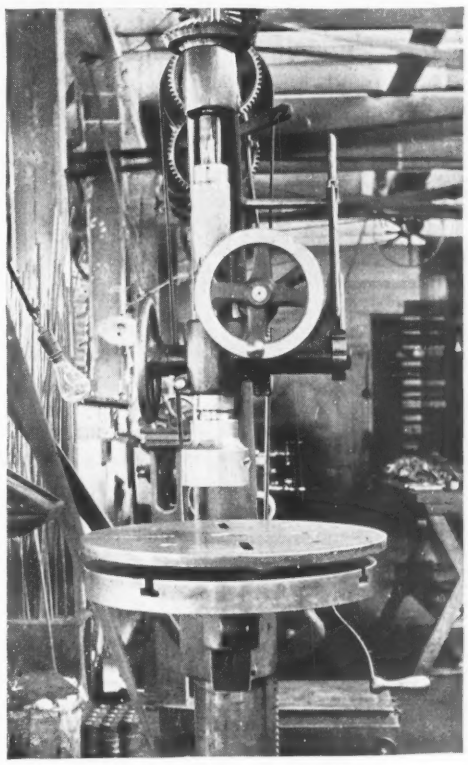
The flexible wheels made by this company are novel and interesting in many ways. They are of the silicate type and very thin for such large diameters, those made for the World's Fair exhibit being about 18 inches in diameter and only 3/8 inch thick. Strange as it may seem, they are used for cutting off stock of all kinds, and are said to give excellent satisfaction in this capacity.

The time taken in the drying and baking makes it necessary to carry a large stock of wheels on hand, as they cannot be turned out by this process in much less than three weeks, which is longer than the average shopman of to-day wants to wait for anything, even a new building. This portion of the work was decidedly interesting, and this did not cease when the machine department was reached.

This is also interesting, being in charge of Mr. Walker, inventor of the Walker Universal Grinder among other things, and about as ingenious a shop manager as one often meets. The Walker grinder is very well known for a comparatively new tool, and little need be said of it save that it is a very complete grinder for any work likely to come up in the tool room.

There are several shop kinks which are interesting to the mechanic, and a few of them are shown herewith. The drill grinder in the tool room (one of the Worcester Tech. grinders) is protected from accidents by bursting wheels by the cast iron ring shown surrounding the wheel; as the work is all done on the side of the wheel, the ring does not interfere with the work in the least.

The drill press photograph shows a system in use here which will be new to most shops and which has several good points. We all know how easy it is to let the drill go through the work into the table—don't need to half try to do it; and when we have a nice job that requires a perfectly smooth and true table, we find it is far from perfect, and the job is not satisfactory. Mr. Walker's plan is to turn up a false table (very much like a face-plate, with slots for drilling into) and dowel it to the drill table, before the drill is used at all. The dowels merely prevent the table from turning and are two in number, made of different sizes to insure being placed in the same position every time. For ordinary drilling, the false table is used and saves the original from being bruised or drilled. When a nice job comes along, the false table is removed and the main table is found in good condition for work. In the photograph the false table is raised slightly to show that there are two tables.



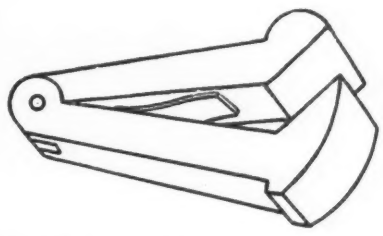
FALSE TABLE ON DRILL PRESS.

For turning hollow work, such as long sleeves, they use pipe centers that are a little out of the ordinary. Where work of this kind turns on the center it soon develops a series of rings which are neither beautiful nor useful. This is obviated here by using a revolving center for the dead or back spindle, fitted with a small key as shown in the line cut. A small keyway is cut in the bore of the work, which insures the centre revolving on the spindle as shown by dotted lines. The center in the live spindle is similarly equipped, except that it does not revolve, although either kind could be used there, as a separate driver is needed for anything but the lightest work.

* * *

BEVEL FILING.

Where there is a great deal of thin work to be filed at an angle—as the beveled edges of gun-lock plates, etc., the contrivance shown in the cut comes admirably in play. It is placed between the jaws of the vise, and firmly holds the object at the desired angle, so that if you file horizontally the plate will be properly beveled. The spring between the jaws serves to open them out as the main vise is opened out.

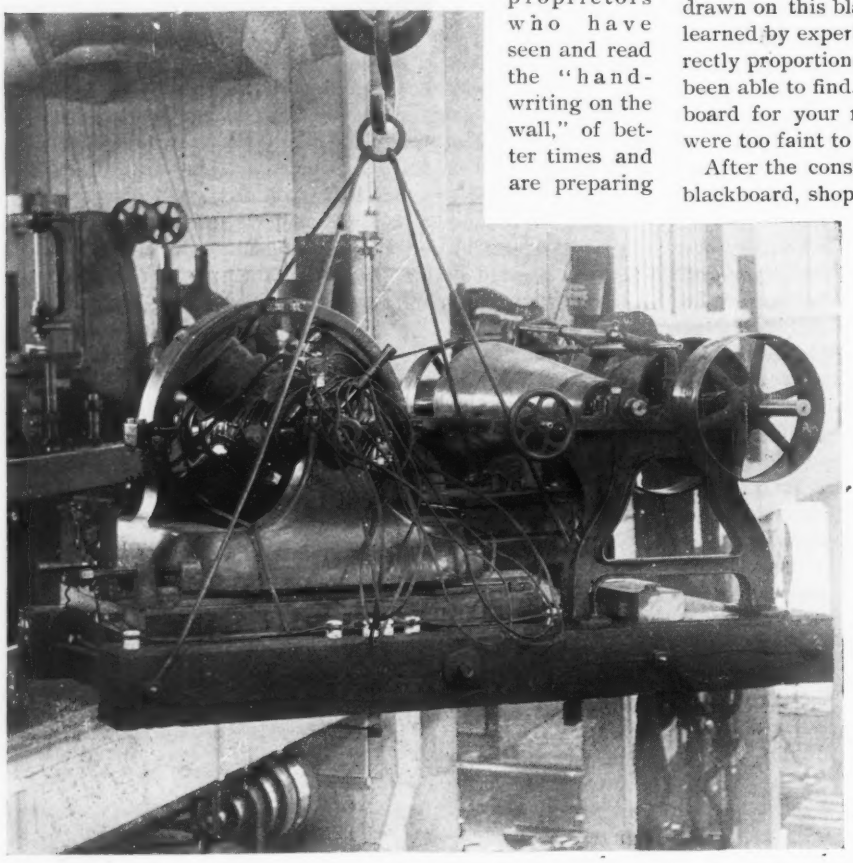


AMONG THE PHILADELPHIA SHOPS.

S. Ashton Hand.

The machine shops in general and the machine tool shops in particular in this vicinity, are not overburdened with orders, and the writer has found it no easy task to find something new in this line.

While business is not booming, yet there are some long-headed proprietors who have seen and read the "handwriting on the wall," of better times and are preparing for their advent by gradually accumulating a stock of finished machines in their store-rooms. They are wise, for when the orders do come, they will come suddenly, and the manufacturers who have something on hand to sell will be pocketing the shekels, while their less wide-awake brethren will look on and kick themselves for being tack-headed jays.



PORTABLE MOTOR FOR TESTING MACHINE TOOLS.

The other day I visited the new plant of the Newton Machine Tool Works at Twenty-fourth and Vine streets, Philadelphia. They occupy a ground space of 100×102 feet and are three stories high. The first floor covers the whole area of the ground plan, while the other two floors are simply galleries on either side of a clear story or runway for a travelling crane. The ground floor is used for the heavy machine tools and for erecting. The first gallery on the south side is occupied by the offices, drafting room and store room for finished machinery, while in that on the north are placed the light machine tools and the tool room.

In the tool room the only machines are grinding machines, on which all cutting tools are sharpened. All special tools are designed in the drafting room and are made in the shop proper, the same as any other job. A peculiar feature in the drafting room is a blackboard about 12 feet square, equipped with a counter-balanced ruler its whole length. The blackboard is made by tacking to the wall pieces of cloth painted with a silicate compound.

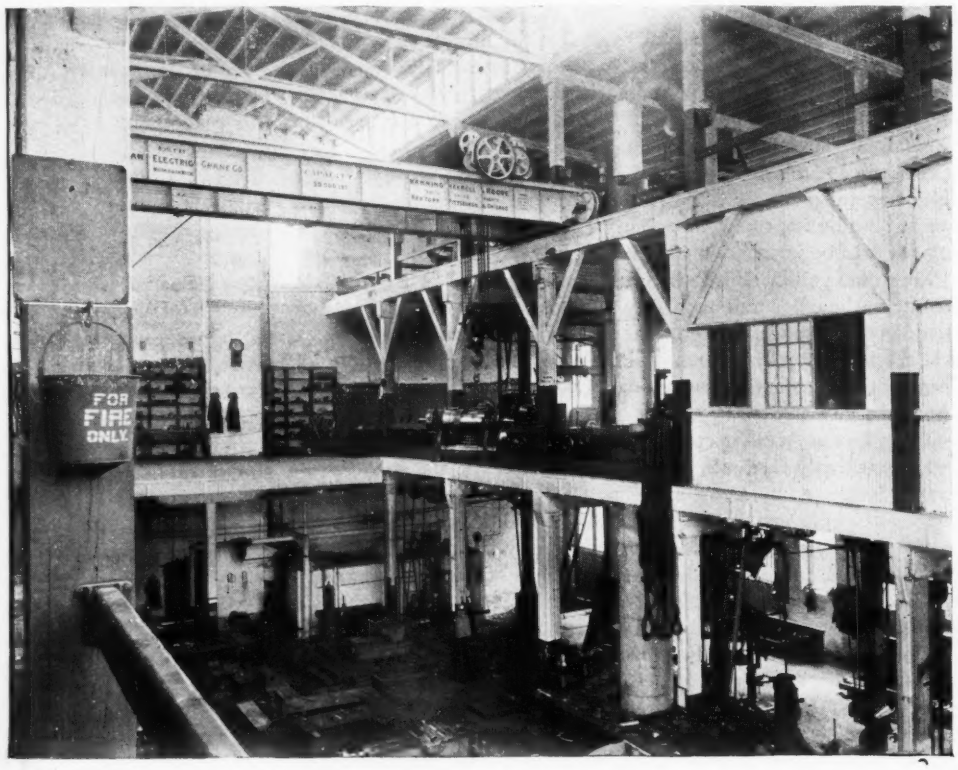
Dividers, triangles, etc., only much larger than ordinary, are used, while the marking medium is a soapstone pencil. Of course a step-ladder is a necessary adjunct.

When a new machine is being designed and after some preliminary sketches are made, full-size elevations and plan are drawn on this blackboard. The manager told me that they had learned by experience that a machine can be more easily and correctly proportioned by this means than by any other they had been able to find. I would like to have photographed this blackboard for your readers, but the marks of the soapstone pencil were too faint to have shown well.

After the construction drawings have been completed on the blackboard, shop drawings are made, traced and blue-printed in the usual manner. Only one size of drawing is used in the shop—14¾×19¾.

All departments of the works are connected with the office and with each other by telephone, each 'phone having its own switchboard attached to it so that one station can "cut in" and communicate with another without the intervention of a "central." The erecting floor and all heavy tools are served by a 15-ton electrically driven travelling crane of the Shaw type, which is so well known as to need no description here. The span of the crane bridge is 33 feet.

I saw this crane put to a novel use during my visit. The shop floor on the Twenty-fourth street side is about 8 feet above the street grade, and to back a wagon into the shop and to have the bed level with the floor necessitates a steeper grade from the sidewalk into the shop than is possible for horses to back a heavily loaded truck up, so they simply attach a rope to the rear axle of the truck and over a snatch-block make the standing part fast to the crane hook, hoist away, and presto! the truck backs up slick as grease. It demoralizes the truckmen though, for they miss lots of opportunities to show that proficiency in profanity so dear to all teamsters when urging their horses to back. Between the efforts of the preachers and



NEWTON MACHINE WORKS, PHILADELPHIA.

engineers, I suppose we will sometime see the day when a man can actually put up the ordinary stove-pipe with moral remarks.

They have a novel portable apparatus in use here for testing machinery after it is finished. It consists of an electric motor and an Evans friction cone on one set of skids. Instead of moving machines under a countershaft to run them while testing, they pick up this apparatus with the crane, take it to the machine to be tested, connect the motor wires to the nearest binding posts, run a belt from a pulley on the friction cone to the driving pulley on machine and all is ready to test. Time consumed, not over ten minutes.

I send a photograph of this machine hanging on the crane, and the other view of the shop shows it hanging on crane also. This is because the views were made during the noon hour and there was no power available to move it out of the road.

As these works are so nearly square it was not possible to get a good general photograph of them, and on the first floor some heavy castings were acting as "view disturbers" and prevented any good views being taken on that floor.

* * *

A FEW OF THE SNARES OF PATTERN MAKING.

JOHN M. RICHARDSON.

All trades, and I suppose professions as well, have their tricks and kinks, best known to themselves, and, at the same time, they have their snares and pitfalls, which are too often manifest to others as well as themselves. Pattern making is no exception to this rule, and while it presents a strong, clear surface in general, still there is thin ice here and there through which the apprentice, the careless and short-sighted man, and even the expert workman occasionally falls.

It is true, as some one expressed it, that "All men make mistakes, but it takes a smart man to get out of one after he has made it." It is my object here to present several of the snares in pattern making that are of every-day occurrence, and while some of them are so simple and self-evident as to seem hardly worth mentioning, still they may perhaps serve as sparks of warning to a reader here and there.

In Fig. 1 A represents a section of a slide 4 by 1 inch to finish on all sides, the finish to be $\frac{1}{16}$ inch. After getting the stock out 1 $\frac{1}{8}$ inch thick, it must be 4 $\frac{1}{8}$ inches wide in order to have an even finish. B and C show extreme cases. It would be exactly the thing to do in case of a piece having a right angle as at B; but at C, in order to get proper finish, the piece would be much more than 4 $\frac{1}{8}$ inches in width. In a job of this kind the stock should first be planed to the proper thickness, then one edge cut to the angle required. Next, gauge the line *x y*, showing the back of the finished slide and also *m n* in like manner. From the intersection of these two lines lay off the required length 4 inches, and draw the same angle as before, only in the opposite direction; next, have another line parallel with this $\frac{1}{16}$ inch from it, and cut the stock to it, making an even finish all around the slide.

Fig. 2 shows the ways for this slide to work in, and has a $\frac{3}{16}$ inch gib to take up wear. If the drawing should happen to reach the pattern maker figured in the manner indicated at A, it is very easy to be led astray unless the finish is laid out around the true dimensions, as shown at B. This should always be done, no matter whether the job is to have loose pieces or a core-box to get the angles.

When possible, lay out work directly on the pattern, and work to the lines. If this is impracticable in some cases, then lay it out on a board, and take measurements from this.

In laying out the finish on the guide at B, Fig. 2, first draw the shape of slide inside the gib shown by K C, C D and D E; next, draw F G parallel with D E $\frac{3}{16}$ inch from it. This gives the finished size of the ways when planed. Now lay out the finish all around this, as shown, and there will be no trouble when the casting reaches the planer.

Fig. 3 illustrates a very simple point, commonly overlooked. At A we will suppose the drawing calls for a finished spot 1 $\frac{1}{2}$ inches diameter and $\frac{1}{4}$ inch high, with a $\frac{1}{4}$ inch fillet. B shows the way it is usually turned, and C the proper way. By referring to B it will be noticed that after the finish is removed, the spot is more than the required diameter, and the fillet also has a larger radius, while at C the part showing the finish has its sides straight and the radius of the fillet is not enlarged, thus leaving the finished boss the size indicated by the drawing.

In allowing finish on work, of which Fig. 4 serves as an example, start with the part having the largest diameter, and turn wide enough to finish on both sides. Then turn all the other lengths to the figures called for by the drawing and have no further thought of finish, except for the diameters.

I once heard of a man who made a cone pulley and kept adding his finish to the width of each step as he went along. The result can be imagined quicker than described.

When a hub is shown with a finished face, and also with a round corner, as shown at A and B, Fig. 5, there are one or two points to consider. If the radius of the edge of hub is very small and equal to, or less than, the amount of finish to be taken off, it is just as well to ignore it on the pattern, and let the machinist take it off when he faces up the hub; but when one is shown with a decided round corner, as at B, it is good practice to turn the round corner, just as indicated, and the finish additional, as at C, but it does very little good to follow the method given at D, where sufficient length of hub is left for finish, but with the round corner coming to the end, to be only partly turned off in the machine shop, leaving a very unsatisfactory looking end having a combination of a sharp edge and a fraction of a round corner.

It very often happens that the core prints on a pattern do not form an unerring guide to the moulder in setting the core, *i. e.*, it can be placed end for end, or else wrong side to, and yet be a perfect fit as far as the mould is concerned. In a case like this, if there is any possibility of getting it wrong, the chances are certainly strongly in favor of the casting coming in that condition, whereupon the pattern maker will blame the moulder and say he set the core carelessly, and the moulder will claim that it fitted all right that way; and how could he tell, he had no drawing to work from as the pattern maker had. In these cases the moulder has the best of the argument, but all trouble of this nature can be most easily avoided in the pattern room by putting on what is known as a guide print, that is, affixing a spot of any size or shape as seems desirable to the main core print, and then cut out a corresponding place in the core-box to exactly match this.

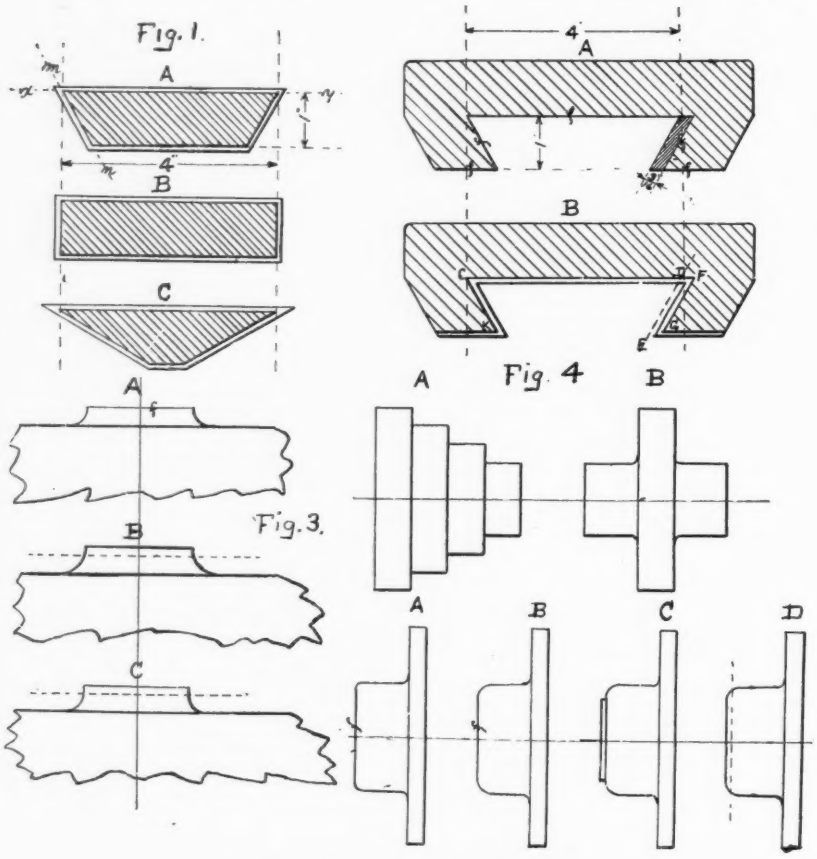
Sometimes precisely the same result is obtained by cutting away a portion of the core print and filling in a place in the core-box instead, which exactly duplicates the part taken from the print. Either one of these precautions just mentioned should always be employed; it takes but a short time to do it, and absolutely prevents a core being set wrong.

Another point which so often proves to be a "will 'o the wisp," to allure and lead the pattern maker astray, is where he is given a drawing and is told that it is for a cheap pattern, for he is very likely to imagine that the figures can be slighted, in his haste to finish the job.

Let us look a moment at the term "cheap pattern," and see what it really implies. It means that a result is sought after, and this result is a good casting, for who ever heard of a person who wanted a poor machinery casting? The pattern is the cause and the casting the consequence, so if we can make it cheap and arrive at the same end, we have fulfilled the conditions.

This can be effected in two ways: first, in the construction, for when a cheap pattern is called for it is almost always for only one or two castings; so it can be made of one, or at least fewer pieces, and in other ways may be less strongly put together, but sufficiently so for its short stay in the foundry; whereas, if it was a standard pattern, everything possible would have to be done,

both for strength and to make it retain its proper shape during its constant use. The second point where we can save time on a cheap pattern is in the finish, and this is quite an item, for it takes time to bring a piece of work down to a perfect surface, and



A FEW OF THE SNARES OF PATTERN MAKING.

applying three coats of shellac and one coat of varnish smoothly sandpapered will produce just as good a result, for it is well to remember that the shine and polish on a pattern does not make a better casting, it is simply a preservative against moisture and and a trade-mark of careful workmanship on a nice job.

There is still one more point to consider, and this is the most important of all. *Be just as accurate with the dimensions on a cheap pattern as on a standard one.* "Hang to your figures," as we sometimes express it, for if the figures are not strictly adhered to, the result will indeed be poor after the piece reaches the machine shop, as the workman there will lay out the job just the same as if the pattern cost three times what it really did, and if the pattern center distances between hubs and spots, and various other dimensions, do not come accurately, then the machinist's opinion of the pattern maker is anything but complimentary, and his reputation for accuracy suffers thereby.

* * *

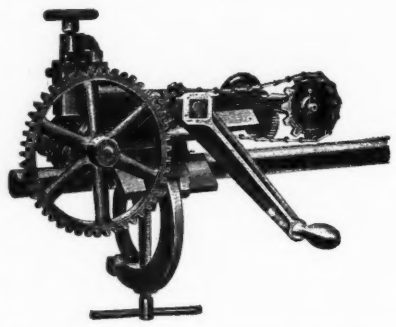
BORING AND TURNING MILL.

This is one of the standard machines made by the Niles Tool Works, of Hamilton, Ohio, and like most of their tools is of very solid construction. It swings 121½ inches in diameter, and when the crosshead is raised will take a piece 54 inches high under the tool-holders. The boring bars have a traverse of 32 inches, and are both counterbalanced. The cone has seven steps for 4-inch belt, and is back-geared. The feeds are operated by a friction disc and range from $\frac{1}{32}$d to $\frac{9}{16}$th of an inch.

The tables have an annular bearing under outer edge, and when heavy work is being done, the step is relieved and table rests lightly on this outer bearing. The style of mill shown is made in different sizes up to 16 feet.

A PORTABLE KEY-SEATER.

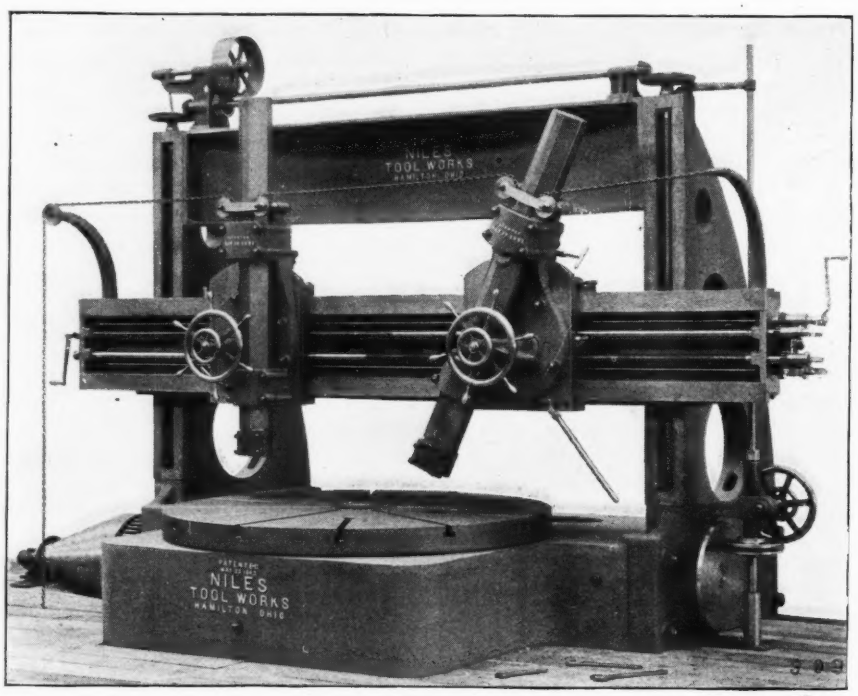
One of the jobs that makes a machinist hate himself when out on repair work is chipping a keyway in a shaft, especially if the keyway must be a long one. It is a tedious job at best and takes lots of time, which is sometimes very valuable when there is a breakdown and the whole plant is idle in consequence. The little machine shown herewith will be appreciated by those who have had this kind of work to do, and we agree with the makers that "no millright or machinist doing erecting or repair work can afford to be without it," especially as the price is quite low. It weighs but 45 pounds, and will mill any width of key-seat from ¼ to 1⅛ inches, and any depth to ⅝ inch, and the operator is said to be able to cut easily a keyway 12 inches long, ⅝ inch wide and $\frac{5}{16}$ deep in one hour; other sizes in proportion.



Each machine is furnished with six milling cutters, so that by placing one or more on the spindle, any keyway between the sizes mentioned can be cut. Hand or automatic feed is provided and a dial indicates the depth of cut in the shaft. It is one of the handiest tools in this line we have seen, and should find favor among machinists generally. Lake Bros., 1645 North Tenth street, Philadelphia, Pa., are the manufacturers.

* * *

It is well to remember that all materials are liable to change shape, and that even heavy masonry foundations for machine-tools are not exempt from this. This is especially true of planers, where the inevitable shock of reversing the table is sure to affect the foundation in a comparatively short time. The best builders, and we might say users also, of planers look closely after their foundations, and test the table frequently to see



BORING AND TURNING MILL.

if they have moved from their originally correct position. This is the only way to feel confident that they are accurate, and a similar test might with advantage be applied to many other tools as well.

* * *

Mr. M. A. Greene, of Altoona, Pa., has been appointed sales agent for the Lidgerwood Mfg. Co., of New York City.

MACHINE SHOP ARITHMETIC.

A series of practical articles clearly explaining the portions of mathematics which will be useful to the men in the shop and engine room.

PRACTICAL QUESTIONS CONNECTED WITH THIS SUBJECT WILL RECEIVE PROMPT ATTENTION.

ONE RULE FOR ALL.—(2).

By John H. Cooper.

Enough has been said to plainly show the application of this rule to the volume of many of the well-known regular bodies. The foundryman and the engineer meet with forms, the contents and weight of which they must know before anything can be done towards the making of them. Many times it will happen, the very dimensions, necessary to solution by the book rules, are not given, which renders the calculation impossible.

How readily, then, these cases can be met by the *one rule;* for sufficient data must be given to permit a drawing of the outline

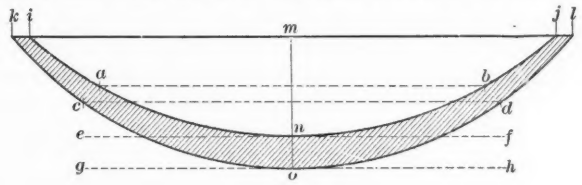


Fig. 1

or central section of the vessel or body to be made, and from these the middle section may be found, whence the solution is easily and certainly obtained.

There are many forms of revolution, resembling a cup or a saucer, such as are frequently "swept up" in loam in iron foundries and used for *soap-pans, stills, retorts* and the like, the contents of which are wanted to be known as well as the weight of the same, and these must be found out before they are cast, before their patterns can be made and, indeed, before the order is given to make them. Three questions are put in the threshold of the business deal: *How many gallons or cubic feet will each hold? What will they weigh? At what price can they be made?*

The inner capacity, when found in terms of cubic inches, may easily be converted into gallons, and the difference of volume between the inner and outer "skins" of these vessels, which represents the body of the vessel itself (oftentimes of very unequal thickness) may be counted in cubic inches, which may readily be converted into pounds. The price per pound for each and every form will by simple multiplication give the cost of the vessel in question.

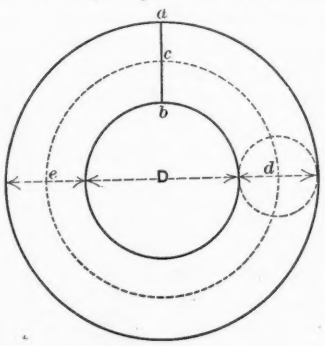


Fig. 2

First of all, when the dimensions are given, a drawing to scale must be made in order to give the form desired, this will enable us to determine the exact middle section diameters, we then proceed as follows:

In Fig. 1 we have the central section of a dish or pan, a saucer like form of vessel, in which the line *a b* cuts the middle section of the inner skin, or content or holding capacity of the vessel, and the line *c d* cuts the middle section of the outer skin. The space between the two skins represents the cubic volume or mass of the vessel itself, which, when found in cubic inches, may be converted into pounds weight.

The form of the rule as it applies to cones solves this problem. For the inner part we have the area of the top, whose diameter is *i j;* the area of the bottom which is o; the curve of the interior touching *e f* at *n;* four times the middle area, whose diameter is *a b*, and then the perpendicular height *m n*, one-sixth of which must be taken as before.

The same process must be gone over for the outside curve, using *k l* for diameter of top, *c d* for diameter of middle section, *m o* for height and o for area of base, because the curve touches the line *g h* in a point. If we now deduct the lesser volume from the greater, we will get the volume of the body of the vessel itself, which is what we sought. Other regularly formed solids can be calculated in the same way.

Then the ring, Fig. 2, may be treated as a solid cylinder of diameter *d* bent around a mandrel of diameter D, the ends meeting on the line *a b*. The length, or perpendicular height of the cylinder, to be taken from the middle dotted circumference *c d e*. If this ring were square or polygonal in section the rule applies equally as well.

The spiroid, Fig. 3, for similar reasons may be regarded as a true cone wound around a cylindric mandrel of diameter D. The diameter of the base is *a b;* the apex of the cone is at *a* and the perpendicular height of the cone is the central dotted spiral *a d e c*, the diameter of the middle section is of course half of *a b*. The method of calculation will then be the same as that already given for the cone. The value of this rule for calculating the weights of the cases of centrifugal pumps and the like, will be apparent from this reference.

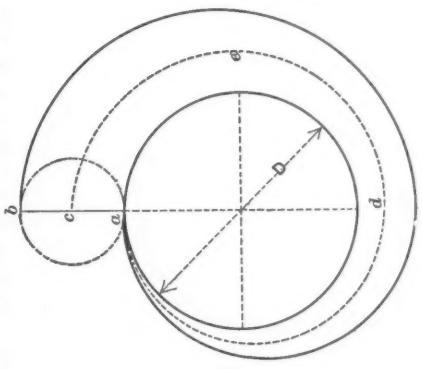


Fig. 3

The volume of the form shown in Fig. 4, called an *ellipsoid*, must be calculated in the same way as directed for the double cone or spindle, which latter it resembles, having rounded instead of pointed ends: that is, find the volume of one-half and then double the result. For this we take the area of the middle section *a b* as the base of one-half the solid; the area of the top is o, as with a cone; the section *c d* is the middle one between *a b* and four times this must be taken, as always, and the sum of these multiplied by $\frac{1}{6}$ the height between *a b* and o for the volume of one-half the whole solid.

We have cut the other half by a plane *g h* and have drawn *e f* midway between *a b* and *g h*. Then, to find the volume of this *frustum*, or part, add together the area of *g h*, the area of *a b*, four times the area of *e f*, and multiply this by $\frac{1}{6}$ the distance between *a b* and *g h*. This product is the volume of the frustum which, if added to the volume of the half just found, will give the volume of the whole ellipsoid "with the end cut-off."

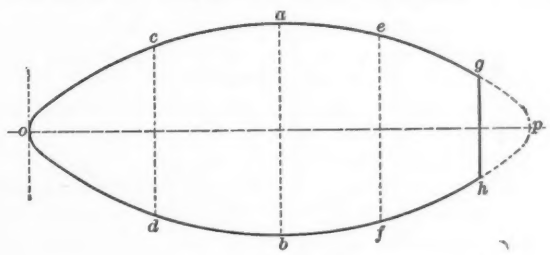


Fig. 4

In this way the segments of other forms may be calculated by dividing them into two or more parts and then finding the volume of each separately.

In books on Mensuration a rule is given called the "Prismoidal Formula;" it is the same as this "one rule for all," but has been applied only to the ascertaining of the volumes of earth and rock to be removed from a railway or a canal cutting, or the like, which take the forms of masses having flat faces of various geometric

figure. The base and the top are usually considered to be parallel with each other for easy figuring, and may not be of the same shape, one may be square, the other triangular, or both may be polygonal, differing in the number of their sides; these sides are joined by plane surfaces. The rule applies as before defined; find the area of the bottom, the area of the top, and four times the area of a middle section (which may require some calculation), then multiply by $\frac{1}{6}$ of the perpendicular distance between the top and bottom planes for the volume of the whole.

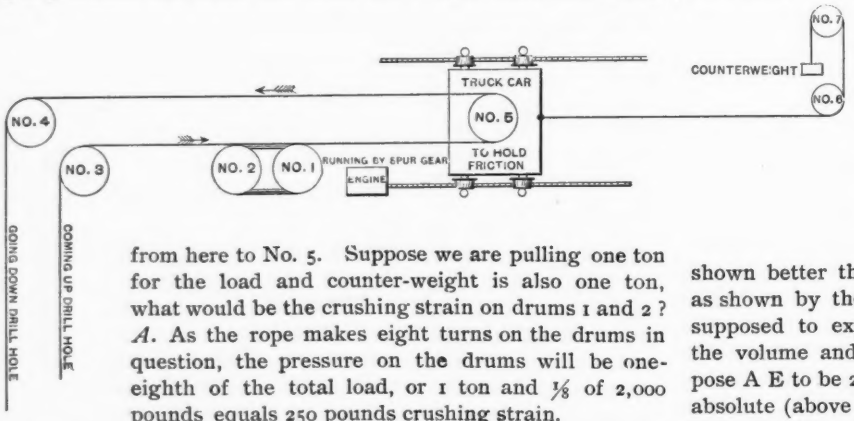
This rule equally applies to wedge-like forms, as in the case of oblique cuts across cones, pyramids, cylinders, spindles and other bodies. This rule is geometrically true, and is, therefore, worthy of general acceptance for these solutions. Once fairly learned, it is easily remembered, and when in mind and found always at finger ends, we may truly say it is needless to seek further for a better rule by which to solve the volumetric contents of all regularly formed solids.

* * *

HOW AND WHY.

A COLUMN INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST. GIVE ALL DETAILS AND YOUR NAME AND ADDRESS, WHICH WILL NOT BE PUBLISHED UNLESS DESIRED.

41. S. F. asks: With the loaded rope leading on pulley No. 1, going around this drum and drum No. 2 eight times, and going



from here to No. 5. Suppose we are pulling one ton for the load and counter-weight is also one ton, what would be the crushing strain on drums 1 and 2? *A.* As the rope makes eight turns on the drums in question, the pressure on the drums will be one-eighth of the total load, or 1 ton and $\frac{1}{8}$ of 2,000 pounds equals 250 pounds crushing strain.

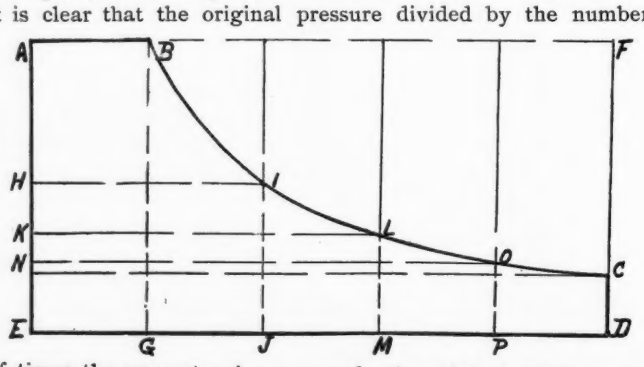
42. R. M. G. asks: Is there any economy in using a condenser where the air-pump is attached to crosshead or other convenient place; does not the apparatus consume more power than the vacuum gives back, and in the case of an overloaded engine, would a condenser attached in this way help it out any? Would not an independent condenser be best? *A.* In a great many cases it is more economical to connect the air-pump direct to the engine than to run it independently, because a large engine is, as a rule, much more economical than a small one, and the amount of power required for the air-pump must be supplied from some source. While there are cases where a condenser is not economical, they are generally to be recommended, depending entirely on whether the gain will exceed the cost of installation, of operation and of water. Independent driven condensers are very convenient and generally advisable for large plants. If the engine will develop more power with the condenser at the same steam pressure and revolutions, then the condenser is beneficial. This can either be tested by indicator, by Prony brake, or by noting amount of machinery it can keep up to speed in both cases. If we could secure our vacuum without expense, as in the case of some one running an air-pump and furnishing water free, the condenser would be clear gain; as it is, the economy must depend on the difference between cost and gain.

43. K. T. T.: 1. What is a good construction for a wall for a small cold storage building? *A.* Avoid wood as much as possible. An outside brick wall 14 inches thick, then 4 inches of pitch and ashes, 4 inches more of brick, a 4-inch air space, and finally 14 inches more of brick, is highly recommended. While this is expensive to erect, a cheaper and poorer wall is a continual expense, as it requires more power to keep the building cool. 2. What is meant by the word "draw," in tempering? *A.* As steel is usually made too hard for use by being dipped into water after heating to proverbial "bright red," it is necessary to soften it a little by heating slowly, and this softening is called "drawing" the temper. For example we say that for springs we "draw" it to a blue, etc. 3. Why do exhaust pipes nearly always point upward instead of downwards or sideways, so as to have fewer bends? *A.* This is usually a matter of necessity, as unless the engine exhausts into a condenser, or possibly in rare cases into a sewer, there is no place to get rid of the exhaust except upwards, where the condensation is either conducted off by a drain-pipe or showered on passers-by, according to the exhaust head used. 4. This will be answered later.

44. J. G. T., Pottstown, Pa., asks what is the difference between bevel and miter gears? *A.* The term bevel gears seems to cover the whole range of gears which transmit motion between shafts not lying in parallel lines. When the bevel wheels are of the same diameter and work together at an angle of 45 degrees, they are called "mitre" gears. 2. What is the difference between gear "teeth" and "cogs"? *A.* When the teeth are solid with the body of the gear they are called "teeth"; when of separate material they are called "cogs." When the cogs are inserted in the rim the gears are called mortise wheels.

45. J. T. W., Ansonia, Conn., says: 1. In Atkinson's "Electric Lighting," it says "with 91.91 volts and .71 amperes, a 16 candle power lamp takes 4.07 watts per candle power." How is this? *A.* Volts and amperes mean in common language pressure and quantity respectively, and *volts* multiplied by *amperes* gives *watts*, the amount of work done, just as foot-pounds represents mechanical work performed. Then as 91.91 volts × .71 amperes equal 65.2561 watts needed for one 16 candle power lamp, it is clear that 65.2561 divided by 16 will give the watts per candle power, or 4.07 watts per candle power. 2. What is the construction of an electric soldering iron? *A.* We cannot go into any details of this, but in brief it consists of a resistance coil, which becomes heated on the passage of an electric current. This heat is transmitted to the work to be soldered through the conducting material which surrounds the coil.

46. A. R. T., Pawtucket, R. I., asks: 1. What is a hyperbolic curve. *A.* This can be shown better than described. Taking an ideal indicator card as shown by the heavy line A B C D E, in which the steam is supposed to expand as a perfect gas, where the product of the volume and pressure always remains the same. Or suppose A E to be 2½ inches and to represent 100 pounds pressure absolute (above vacuum). The cut-off is at B, and from here the pressure falls as the expansion takes place. Calling A B 1 inch, then the area A B G E equals 2½ square inches. When the steam expands to the point I (and the piston moved twice as far as from A to B) the distance I J will be 1¼, or half B G (as the same volume of steam occupies *double* the space and is consequently at *half* the pressure). Then we have H I J E equal 1¼ × 2, or 2½ square inches as before. When the piston moves another fifth of its stroke, from J to M, we find the pressure *one-third* the original, as the same steam now occupies three times the space, and can prove the areas the same as before. So it is clear that the original pressure divided by the number



of times the present volume exceeds the original volume, will give the pressure at any point of the stroke. The hyperbolic curve then is a curve in which the horizontal distance from the vertical line A E multiplied by the vertical height from the base is the same at any point of the curve. This can be readily proved by laying out a few ideal cards as described. 2. What are hyperbolic logarithms? *A.* These are numbers which have been calculated to give the area of the space included between a hyperbolic curve as B I L O C and the base line as G J M P D, and they are largely used in calculating mean effective steam pressure, which is of course in proportion to the area of the card taken. They can be found in any engineer's pocket-book. While the piston moves from E to

G the steam exerts full pressure, but the work done by expansion is easily found by hyperbolic logarithms. Taking from Haswell the hyperbolic logarithm for 2, 3, 4 and 5, we have .6931, 1.0686, 1.3863, 1.609. Supposing the card to end at I J, then the expansion rate is 2 (or steam after expansion occupies twice its original volume), and the work done by the expansion is .6931 of the work done before cut-off, the total work being 1+.6931 instead of 2 if the steam was carried full stroke. Taking the card shown with cut-off at $\frac{1}{5}$ (or 5 expansions), we find the work done by expansion is 1.609, or total work equals 1+1.609 instead of 5 if steam had been carried full stroke. To find mean effective pressure, or M. E. P., we say:

$$\text{M. E. P.} = \text{Pressure} \times \frac{\text{hyper. log.} + 1}{\text{expansions}}$$

or calling pressure 100 pounds, we have

$$\text{M. E. P.} = 100 \times \frac{1.609 + 1}{5} = 52.18 \text{ pounds.}$$

This does not take into account any back pressure, as this diagram is not supposed to have any. When any exists it must be deducted to find mean *effective* pressure.

47. R. A. S., Worcester, Mass., asks: 1. What is squaring a circle? *A.* This is generally understood to mean the finding of a square which shall exactly equal in area a circle of given dimensions. But as we can only approximate (very closely, however) the area of a circle by squaring its diameter and multiplying by .78539+ to as many figures as deemed necessary, but never coming out exactly even. For all practical purposes we use .7854, but we cannot, strictly speaking, square a circle perfectly.

48. B., Brighton, Mass., asks: 1. How can I line up an engine before the line shaft which it is to drive is in place? *A.* Strictly speaking, in such a case the line shaft must be set to the engine, but it can generally be learned very nearly where the shaft will be, either from a careful inspection of the building, walls, etc., or a knowledge of the plans to be used. If you *must* set the engine first, then the shafting must be set to line with it, or several unsatisfactory belt persuaders will be required to keep it on the pulleys. 2. How many pounds of air are required to burn one pound of coal? *A.* Theoretically, 12 pounds; in practice, from 18 to 24 pounds, as you will find in F. F. Hemenway's article on page 139 in the January issue.

* * *

THE FIRST PRINCIPLES OF MECHANICS.—6.

THE ELEMENTS OF MACHINES.

LESTER G. FRENCH.

THE PULLEY.

The pulley, as a machine element, consists, in its simplest form, of a grooved wheel or sheave turning within a frame, called a block, by means of a cord or rope which passes over it. Combinations of these blocks are used in order to gain a mechanical advantage in raising weights.

In Fig. 26 is a fixed and a movable pulley. The fixed pulley A, and also one end of the rope, is attached to the beam overhead, while pulley B may be raised or lowered through the action of the rope. The distance through which B and hence the weight W move is equal to one-half the movement of the free end of the rope. The applied force P, therefore, acts through twice the distance passed through by the weight, and will raise an object whose weight is equal to 2 P, neglecting, of course, all frictional losses. As the rope passes freely over the pulleys, the stress is the same at every point and is equal to the pull P. Assuming P to be 100 pounds, the pull exerted in either direction by the rope at sections *a*, *b* and *c* would therefore be 100 pounds, and hence the forces supporting W would be 100 + 100 = 200 pounds, the pull upon eye-bolt *c* would be 100 pounds and the forces acting upon eye bolt D 100+100=200 pounds.

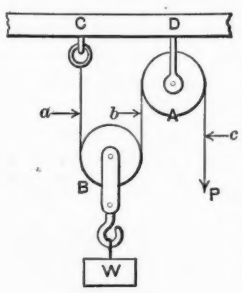


Fig. 26

In Fig. 27 are represented a combination of a double and a triple block. The pulleys of each turn freely upon the same pin as an axis, and for convenience in illustration are drawn with different diameters, this method serving well to show the principles of operation. In Fig. 28 are the same blocks, but with their positions reversed, the triple block being the movable one and the double block being fixed, while the end of the rope is here made fast to the upper or fixed block instead of to the movable one, as in Fig. 27. In either case, by the principle of work the applied force P, times the distance through which it moves, must equal the weight W, times the height that it is raised. Suppose W and the movable block to be raised bodily one foot without pulling at P. In Fig. 27 there would then be one foot of slack in each of the parts of the rope numbered from 1 to 5, or five feet in all, and to take this up the free end of the rope would have to be pulled down five feet, which is five times the distance moved

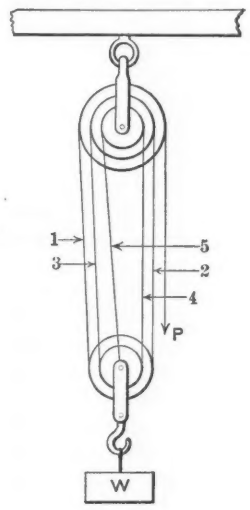


Fig. 27

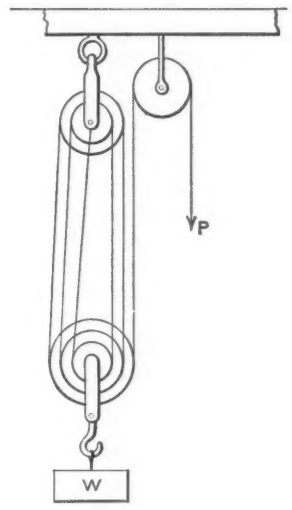


Fig. 28

through by the weight W. Hence, in lifting the weight a given distance, the force P moves through five times this distance; and applying the principle of work, P × 5 = × W 1, or an applied force of one pound will be sufficient to lift a weight of five pounds. By similar reasoning it will appear that as arranged in Fig. 28 an applied force of one pound will lift a weight of six pounds, there being six parts of the rope in which slack can be taken up instead of five, as before. Whatever the arrangement or number of the pulleys, the weight that can be raised can be calculated by observing the relative distances passed through by the two forces P and W. It should be noticed, however, that *the resistance that can be overcome is always equal to the applied force multiplied by the number of the parts of the rope that engage with the movable block*, which is a convenient rule to use. Thus, if there were seven parts springing from the movable block, a force of 100 pounds would overcome a resistance of 100×7=700 pounds, neglecting frictional losses.

This rule may also be arrived at by considering that the force P produces a uniform stress equal to P throughout the whole length of the rope, as was mentioned in connection with Fig. 26. In Fig. 27, for example, the tension in each of the numbered parts is equal to P, and the total upward force supporting the weight is equal to 5 × P.

In the foregoing it is assumed that the supporting ropes all hang vertically. In practice they usually do, very nearly. In case they shouid not, however, the problem is more complicated.

THE SCREW.

By this time the universal character of the principle of work must be apparent, even to one who but imperfectly understood its importance before. The law that work received equals work delivered, is everywhere true, if we disregard the losses of transmission. In the case of the screw the initial force moves through the circumference of a circle, the point of application usually being at the end of a crank or bar, at the surface of a pulley or applied in some similar manner. A screw may be defined as a cylinder around which threads are wound in successive coils or helices, equally spaced. The pitch of a "single-threaded" screw is the distance between like points on successive threads measured on a line parallel to the axis of the screw. The amount that a screw advances in one turn is equal to the pitch, and in fractional turns it is equal to the same fraction of the pitch. Thus, if a screw is given one-fourth turn it advances one-fourth of the pitch, and the ratio is the same as though the screw were supposed to make one complete turn and to advance a distance

equal to the full pitch. *Hence, we have for the screw that the applied force multiplied by the circumference of the circle described by the force, equals the resistance multiplied by the pitch.*

Example 1.—A forcing press has a single pitch screw of four threads to the inch, and it is desired to exert a pressure of five tons, using a lever two feet long in the head of the screw. Neglecting friction, what force must be applied at the end of the lever? Circumference described by the end of the lever $= 2\times2\times12\times3.1416=150.8$ inches, the circumference being obtained in inches to correspond with the pitch.

Work done at end of lever in one turn $=150.8\times$ force.

" " by screw in one turn $= 5\times2{,}000\times.25 = 2\ 500$ inch-pounds.

Hence, $150.8\times\text{force} = 2500$.

$$\text{Force} = \frac{2500}{150.8} = 16.6 \text{ pounds, nearly.}$$

MACHINE EFFICIENCY.

Thus far in problems of work we have neglected entirely the effect of frictional losses, which in many cases require a greater expenditure of power than for the operations actually performed by the machine.

The efficiency of a machine is the ratio of the work got out of a machine to the work put in, and is obtained by dividing the former quantity by the latter. If 1 000 foot-pounds of work were done by a machine in a given time, and 1 000 foot-pounds were put in in the same time, the efficiency would be equal to $\frac{1000}{1000}=1$, or 100 per cent.; but if only 250 foot-pounds were done by the machine, the rest being absorbed by friction, the efficiency would be $\frac{250}{1000}=.25$, or 25 per cent. The efficiency of a machine can never be greater than *one*.

Example 2.—In Example 1, if it were found by experiment that in order to exert a pressure of 5 tons, a pressure of 40 pounds upon the bar were required, what would be the efficiency of the apparatus?

Work put in during one turn$=40\times150.8=6\ 032$ foot-pounds.

Actual work done by screw $=2\ 500$ foot-pounds.

$$\text{Efficiency} = \frac{2500}{6032} = .414, \text{ or } 41.4 \text{ per cent.}$$

Example 3.—It a block and tackle rigging with three ropes running from the lower block has an efficiency of 65 per cent., what weight can be raised if the force applied at the end of the rope is 100 pounds?

In raising the weight one foot the work put into the tackle would be 300 foot-pounds.

Work done by tackle $= W\times1$ foot-pounds.

$$\text{Efficiency} = .65 = \frac{\text{work done}}{\text{work put in}} = \frac{W}{300}$$

Whence, $W = 300\times.65 = 195$ pounds.

GRAPHICAL REPRESENTATION OF FORCES.

A force possesses three prominent characteristics which, when known, determine it. They are: *its direction, place of application* and *magnitude*. The *direction* of a force is the direction in which it tends to move the body upon which it acts. If not influenced by any other forces, this will always be along a straight line. The *place of application* of a force is generally, though not always, taken at a point, as at the center of gravity. The *magnitude* of a force is measured in pounds.

Previously we have represented forces which have been supposed to act at a given point, or in certain directions, by means of straight lines and arrow-heads, this being a natural and convenient way to do. It can be shown, moreover, that this method serves to represent very accurately the three characteristics mentioned above. The straight line indicates the line of action of the force, the arrow-head the direction in which the force is supposed to act along the line, and the length of the line the magnitude of the force, a suitable scale being adopted. Thus, if a scale of $\frac{1}{16}$ of an inch to ten pounds were used, a line $2\frac{1}{2}$ inches long would represent a force of 400 pounds. The point of application may occur at any point on the line, but it is generally convenient to assume it to be at one end.

Fig. 29

To illustrate, in Fig. 29 a force is supposed to act along the line A B in a direction from left to right. The length A B may be made to show the magnitude of the force. If A is the point of application, the force is exerted as a pull, and if B should be as sumed to be the point at which it acts, it would indicate that the force was exerted as a push. The single force which will produce the same effect upon a body as two or more forces acting together upon it is called their *resultant*. The separate forces themselves, which can be so combined, are called the *components*. The process of finding the resultant of two or more forces is called the *composition of forces*, and of finding two or more components of a given force, the *resolution of forces*.

PARALLELOGRAM OF FORCES.

In Fig. 30, let A and B be two pulleys which are pivoted to a to a board, and around which a cord is passed, having weights P and Q at the ends. Near the center of the cord a third weight, R, is suspended as shown. We will assume that the three weights are so proportioned that they will come to rest in the positions shown, and thus the point O will be acted upon by three forces in equilibrium, whose lines of action lie in the directions taken by the three parts of the cord. It is obvious, moreover, and this point should be carefully noted, that under these conditions the force acting along O C must be exactly equal and opposite to the resultant of the forces acting along O A and O B. Now measure along O B the part O *b* containing as many inches as there are pounds in the weight Q, and along O A the part O *a* containing as many inches as there are pounds in the weight P. With a pencil, draw the lines O *a* and O *b* upon the supporting board and complete the parallelogram O *a r b*. Then O *a* and O *b* will represent the magnitude and direction of the forces acting along O A and O B, and upon examination it will be found that if the diagonal O *r* be drawn, it will extend in the same line as the cord O C and will contain as many inches as there are pounds in R. Therefore, O *r*, being opposite to O C, represents in magnitude and direction the resultant of forces O *a* and O *b*.

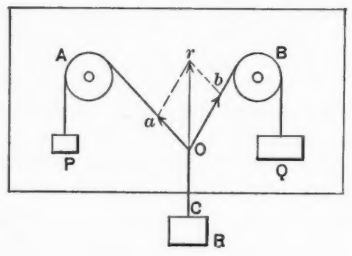


Fig. 30

The foregoing is an experimental proof of the principle of the parallelogram of forces, which is as follows:

If two forces applied at a point are represented in magnitude and direction by the adjacent sides of a parallelogram, (A B *and* A C *in Fig. 31*), *their resultant will be represented in magnitude and direction by the diagonal* (A R) *lying between those sides.*

As an illustration of the use of the parallelogram of forces, let it be required to find the force acting through the connecting-rod of a steam engine due to the steam pressure upon the piston. In Fig. 32 the steam pressure is transmitted through the piston-rod P A, and at the cross-head A is resolved into two components, one along the connecting-rod and the other at right angles to the piston-rod. This is due to the angle made by the connecting-rod which creates a pressure upon the guides. Since the decomposition of the force occurs at A, from this point draw the line A R, representing in magnitude and direction the force of the steam pressure against the piston. Draw an indefinite line A E at right angles to the piston-rod, and from R draw R B and R C

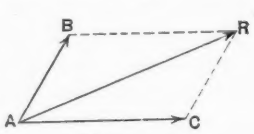


Fig. 31

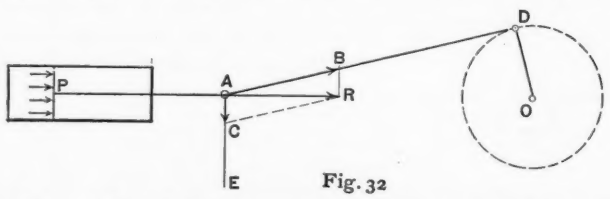


Fig. 32

parallel to A E and A D respectively. Then the points of intersection, B and C, will determine the lengths of the component A B acting along the connecting-rod, and of the component A C perpendicular to the guides.

EXERCISE 6.

1. The pitch of a screw in a screw-press is one-half inch and the length of the lever 20 inches. If a force of 30 pounds be applied at the end of the lever and the screw exerts a pressure of 5 000 pounds, what is the efficiency of the press?

2. With the arrangement shown in Fig. 33 for balancing the bars of a boring and turning mill, consisting of a weighted chain fixed at one end at A and passing over pulleys D and B attached to the head, and pulley C attached to the bar. (a) If the bar weighs 250 pounds, what weight W would be required to supply it? (b) How heavy a weight would be required if two such heads were used, the same chain serving for both?

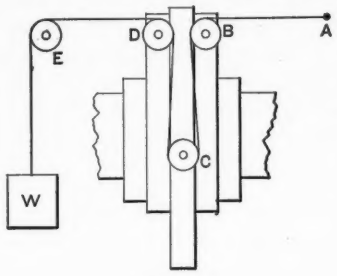


Fig. 33

3. If the efficiency of a set of blocks and tackle having 4 ropes running from the movable block is 75 per cent., what weight could an applied force of 125 pounds lift? (b) With an efficiency of 65 per cent., how many ropes would be necessary to lift 600 pounds?

ANSWERS TO EXERCISE 5.

1. (a) Moment of steam pressure $= 4.91 \times 3 \times P = 14.73\ P$.
Moment of lever $= 15 \times 15 = 225$.
Moment of weight $= 40 \times 25 = 1000$.
Whence $14.73\ P = 1025$.
$P = 83.16$ pounds.

(b) The positive moments are: $15 \times 15 = 225$ and $25 \times W$. Negative moment $= 1281.5$. Subtracting, $1281.5 - 225 = 1056.5$; dividing, $1056.5 \div 25 = 42\frac{1}{4}$, nearly $= W$.

2. 112.22 pounds.

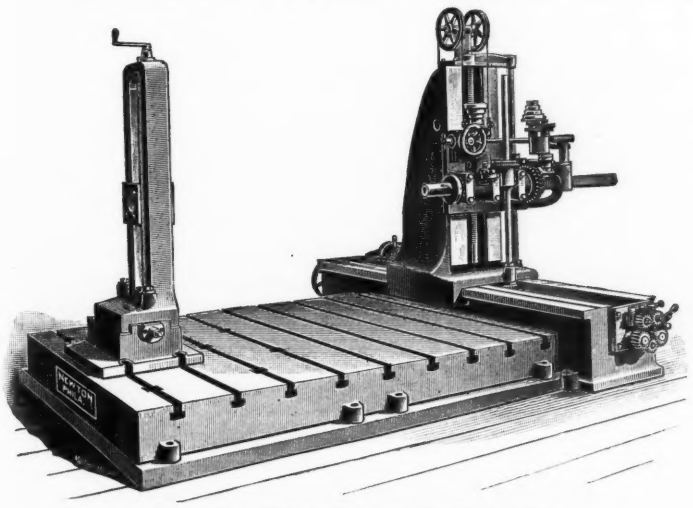
3. 487.5 pounds.

4. $1000 \times 35 \times 18 = W \times 6 \times 20$, whence $W = \frac{630000}{120} = 5250$ pounds.

* * *

HORIZONTAL FLOOR BORING AND MILLING MACHINE.

We illustrate herewith a new horizontal floor boring, drilling and milling machine, built by the Newton Machine Tool Works, of Philadelphia. These machines are designed for all classes of boring, drilling and milling, and they cover a greater variety of work than any other class of machine tools. Many operations can be finished on this machine, by the use of a milling cutter, that would require a very large and expensive planing machine for the same work, besides doing the work more rapidly. Many operations, especially where a rotary table is used, can have the entire work finished with one clamping, doing the boring, drilling, tapping and most of the finishing with one setting. This machine, as can be seen by the illustration, is made exceptionally strong, the upright being proportioned to withstand heavy work.



HORIZONTAL FLOOR BORING AND MILLING MACHINE.

The feed mechanism for the bar has many suitable changes for fine roughing cuts to fast finishing cuts. The same feed mechanism controls the feed of the head on the upright and of the upright on the column for milling. The head is counterweighted and has a quick movement on upright, while the upright has a quick power movement on bed, all of which the operator can control without moving from his work. The boring-bars of these machines are all large, with a long, heavy feed.

They are built in three sizes. The No. 1 has a boring-bar 4 inches in diameter and an automatic feed of 32 inches; the No. 2 has a boring-bar 5½ inches in diameter and an automatic feed of 48 inches; the No. 3 machine has a boring-bar of 7 inches in diameter and an automatic feed of 60 inches.

Machines of this description can be made to any desired height or length. The outside support for the bar, as shown, can be clamped in any position on the work-table and has a separate adjustment for convenience in setting the support central with the boring-bar. The boring-bar of the machine is driven with a triple phosphor-bronze worm-wheel with a hardened steel worm, which insures a steady, even motion and gives great power to the cut.

* * *

WHAT MECHANICS THINK.

THIS COLUMN IS OPEN FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE. WRITE ON ONE SIDE OF THE PAPER ONLY, AND BOIL IT DOWN.

WHEN SKETCHES ARE NECESSARY TO ILLUSTRATE THE IDEA, SEND THEM ALONG—NO MATTER HOW ROUGH THEY MAY BE, WE WILL SEE THAT THEY ARE PROPERLY REPRODUCED.

SHOP FLOORS—FRICTION.

I notice in your last paper an inquiry for the best kind of a shop floor. I think the best kind of a floor where there is no basement underneath the building, is made by having strong floor beams supported by pillars and the space between these beams filled in with good concrete, over which is placed the board flooring securely nailed to the floor beams. This will give a solid floor and will do away with the dirt which is formed from the abrasion of the surface of a concrete floor and it is much warmer to the feet at all times of the year.

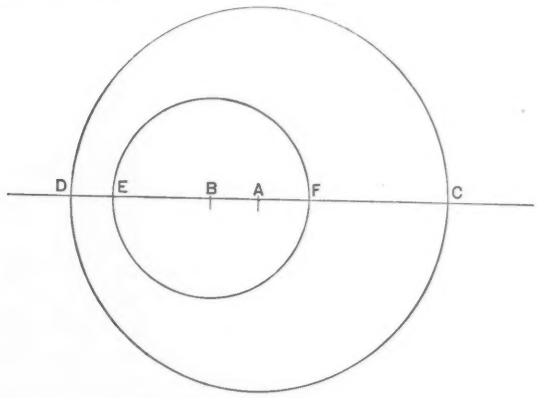
I notice, also, some remarks regarding end thrust of shafting when in motion and the ease with which a properly adjusted shaft may be pushed endwise when moving. The explanation of Mr. Bollinckx does not seem to me to explain the matter very clearly. My own view of the case would be as follows: When the shaft is at rest the particles of oil underneath are forced out from beneath the shaft, allowing the shaft to rest closely on the bearings and to fit them so tightly that there will be much cohesion, making it difficult to push the shaft lengthwise. When the shaft is in motion, it is in reality floating on the lubricant, and may then be pushed easily on the same principle that a stick floating on water is capable of being moved endwise more easily than one resting on the ground. I would like to know what others think of this explanation.

J. P. WILLIAMS.

Providence, R. I.

THROW OF ECCENTRICS.

To find where the greatest throw of eccentric is, find its exact center as at (A), then find the exact center of the hole for shaft as at (B). Draw a line through these two centers and cut the circumference at (C) that point is the greatest throw of eccentric.



If this is not right, please correct, as it may be of benefit to others as well as myself.

R. W. G.

[Another way is to take a pair of calipers and placing one point inside, find the greatest distance between the outer edge and the bore as F C; this gives the point of greatest throw. An easy way to find the throw of an eccentric is to measure the *least* distance between the bore and outside as D E, and also the *greatest* as F C, the *difference* giving the throw of eccentric. ED.]

A HANDY FACING TOOL—A FILE HOLDER.

In machine construction it often occurs that nuts are so placed that their seats are inaccessible to ordinary tools, and if left rough

and uneven, the strength of bolt or stud is greatly impaired.

Fig. 1. Shows a tool which faces nut seats nicely and which is

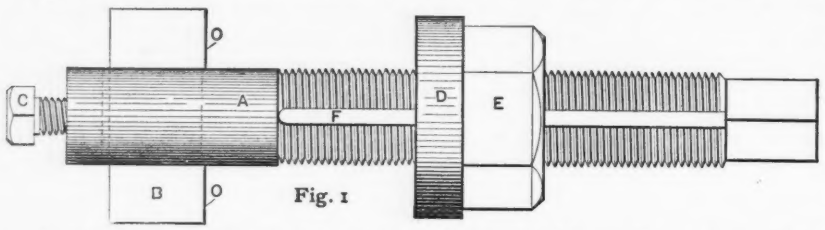


Fig. 1

applicable to other classes of work as facing ends of boxes for collars on shafts, etc.

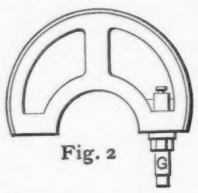


Fig. 2

The body of tool A is threaded as shown, and has a keyway F cut through the threaded part. Washer D has a feather sliding in keyward to prevent it backing off nut E when working the tool.

A number of cutters of different lengths are provided, one of which is shown at B with cutting edges at O.

The diameter of shank is 1 inch and when it is used in larger holes bushings are used to fill vacant space.

Fig. 2. Shows it in use on a half eccentric.

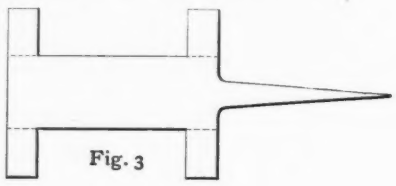


Fig. 3

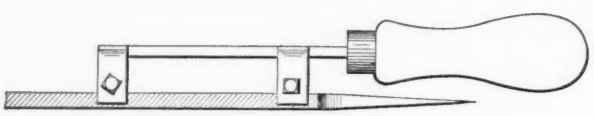


Fig. 4

Fig. 4. Shows a convenient handle for surface filing which holds the file firmly and carries the operators hand above the work.

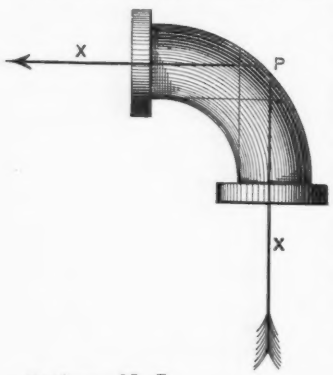
It is cut from 3-16 inch boiler steel in the shape shown in Fig. 3 and the legs are bent at right angles along dotted lines, and drilled 3-8 inch from the ends for 1-4 inch bolts.

One size will of course take only one width of file, but one made for a 14 inch flat file will commonly do for most work.

Corning, N. Y. FRED E. ROGERS.

CALCULATING WATER PRESSURE.

Will some of your correspondents be kind enough to give the rule for calculating the pressure on an ell, with water flowing through a pipe; say 100 pounds per square inch, velocity of 150 feet per minute, also if the strain on the threads where pipe screws into the ell is not greater than at other joints—and does not the strain on ell increase with the velocity, instead of pressure of water; as with water at rest—the strain on ell would be as in the rest of pipe. The sketch shows my meaning.



Wilson, N. C. H. E. BENTON.

BAYBERRY TALLOW FOR PATTERNS.

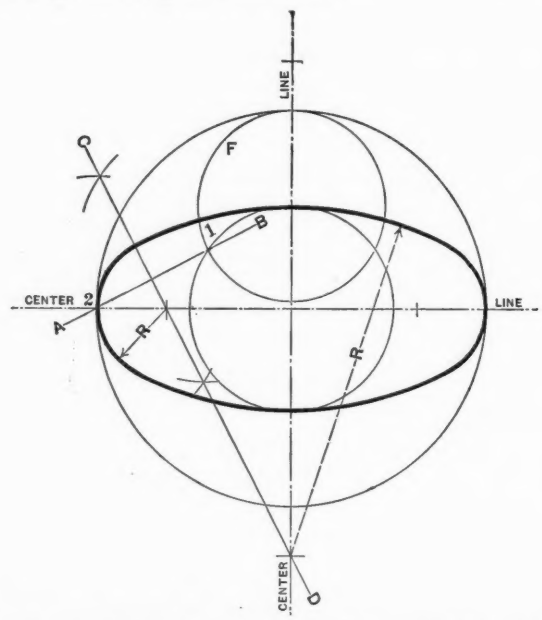
In answer to a query regarding Bayberry tallow, Mr. Richardson replies as follows. Please tell your correspondent that a drug store is the place where I have obtained Bayberry tallow, and should suppose any well appointed store of that kind ought to carry it.

Ten or fifteen cents worth will last a long time on small patterns. It is very much harder than beeswax, a sort of a greyish color and is brittle; also has a strong aromatic odor not unpleasant to me at least, and is procured from Bayberry bushes growing wild every where near the coast. It is a sort of blush or tallowy formation which gathers on the outside of the berries at a certain time of the year; these are boiled in water, when the tallow rises to the surface and is thus separated. To use it successfully on iron patterns, a given quantity should be put in a tin box, for instance, and melted slowly by placing the box in boiling water, taking care not to mix water and tallow together. Next add about the same quantity of turpentine to the tallow and mix well; that is, turpentine and tallow, half and half. Keep this away from fire for it is very inflammable. When this is cold it is like salve or butter, and can be rubbed over the pattern with a rag. It is better to heat the pattern somewhat first, as the tallow will not chill so soon. When the pattern is cold it will, if rubbed, present a beautiful hard shiny surface, that will leave the sand in an elegant manner. It is better to rust the pattern before the tallow is applied if many castings are to be made.

Attleboro, Mass. JOHN M. RICHARDSON.

TO FORM AN ELLIPSE.

In a late issue of your paper, I read an article on the "Ellipse," by Mr. Louis Rouillion, which prompts me to send the following method used by some draughtsmen, pattern and boiler makers which was given me by an "old-timer."



Take the difference between the major and minor axis as a radius, and on the vertical center line describe a circle (F.) and at its intersection with the minor axis as one point, (1.) and the intersection of the horizontal center line and the major axis as another, (2.) draw line (A B), and bisect, using points 1 and 2 as centers. Then draw line (C D) and its intersections with the vertical and horizontal lines will give you the centers for the small and large radius, (R) of ellipse.

Hoping this may be of benefit to your readers, as many "pointers" in your valuable paper have been to me, I beg to remain.

Brooklyn, N. Y. A SUBSCRIBER.

PROFESSIONAL VS. MECHANICAL ADVICE.—JOULE'S EQUIVALENT.

Mr. Podunk, in March issue, puts the matter of consultation in matters mechanical, in a light that is both amusing and instructive. The only trouble is that the doctors and lawyers will not read it. What, they will say, does a mechanic amount to anyhow? But every mechanic ought to read what Mr. Podunk says. There is a world of truth covered up in it.

What Mr. Podunk has to say reminds me of an actual occurrence. Some years aback a rather popular surgeon and physician had engaged himself to deliver a lecture before some medical society or other, and, like a wise man, had prepared his lecture well beforehand; but alas! he had used the steam engine pretty promiscuously in illustration of the points he made in surgery and medicine.

It had happened that I had had his attention not long before for which I had paid him a good round bill, but he had, as I thought, shown himself skilled and I was well satisfied. I suppose it was the acquaintance thus brought about that prompted him to call on me with his lecture, just for the purpose of verification, of course, and I pointed out where every one of his illustra-

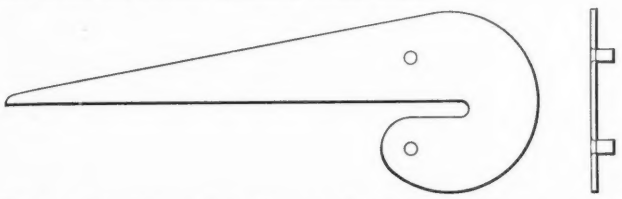
tions were wrong. I take no credit for having done so; any bright school boy could, perhaps, have done the same. But it took a good hour's time, and I do not believe he was even satisfied that he was wrong all the way through.

At the conclusion of the interview I received one of the most polite "Thank you ever so much" you ever heard. That is all I ever did receive. In justice, perhaps, I should say that I had no professional *shingle out;* he did have.

I am pleased with Mr. Taylor's very courteous attention to my foot-note in January issue in relation to Joule's equivalent. I am aware of the attention that has been given this matter. Perhaps I did not make the foot-note clear enough; very likely not. What I meant to express was that, personally, I am insufficient authority for disputing Joule, and that furthermore I thought it advisible to keep right to the 772 equivalent, whether one happened to be in Liverpool or New York, until there was more reason for changing it than is at present apparent. It will not lead us far astray. However, Mr. Taylor has my thanks. F. F. HEMENWAY.

A CONVENIENT CENTER-SQUARE.

This is a very handy little tool, which should be found in every machinists' tool chest. It is especially convenient for marking off the centre line of keyways and similar work, as it can be used either from the outside or inside of the hub.



It is very easily made, as it consists of a plate of thin steel with two round pins set in it at equal distances from the center edge and perfectly square with it.

It is the handiest form of center-square I have ever used and think others will also appreciate it. M. M.

Peterboro, Canada.

TAKES EXCEPTION TO MR. PODUNK.

I noted in your February issue Mr. Podunk's remarks on drafting room economy, and his quotation from the manager of a large tool building works that "The mistakes of their drawing room cost as much as the salaries of the men." Now, I am not an aggressive man, and furthermore, I know it is risky to strike out without knowing who is going to be hit, but I am going to put myself on record as saying that any manager who makes such a statement is either not well posted on the work of his drawing room, or else is a poor manager. No drawing room which is so poorly superintended as to allow such work is worthy of the name, and it is poor business management that allows such a condition of things to exist. I agree with Mr. Podunk, that it is economy to employ first class draftsmen only, but I do not think a man needs to spend much time at the lathe or planer to discover that the machine has a limit and that we can neither take a chip off a locomotive driver in a 16 inch lathe nor surface down a massive engine bed on a 4 foot planer. Shop training is an excellent thing for anybody, but good designers acquire their expert faculty largely through intimate contact with shop men, and keen observation of shop methods. A good draftsman will get more points from fifteen minutes talk with the shop foreman over his drawing board than he would in the same number of hours spent in striving to acquire manual skill to finish the product. I think that in the case of the wofully inefficient drafting room cited by Mr. Podunk, there must have been locks on the doors to prevent any possible contact with the choice body of draftsmen enclosed, and locks on the brains of each draftsman to prevent any common sense from getting in, and a lock on the chief draftsman's office door to prevent any possible superintendence of his men, and to prevent the manager from interfering with his complacent solitude. CHAS. L. GRIFFIN.

Springfield, Mass.

* * *

OUR interesting contemporary, the *American Machinist*, has again added to its efficient editorial staff, Mr. Edward P. Buffet, a graduate of Stevens Institute, being the latest acquisition. There has been a marked improvement in its typographical appearance since the change of management; artist Donnell's work on the illustrations is also very noticeable.

MACHINERY'S REGISTER.

Any Superintendent, Foreman, Machinist, Engineer, Draftsman, Pattern Maker, Moulder—any person connected with the machinery trades who is seeking a position, can have his name and address and a statement of his qualifications placed on file in our REGISTER for the convenience of those seeking such service as he has to offer, by sending us the necessary information and ten cents in stamps, which is intended to cover only the actual cost to us. Sample statements are given below:

FOREMAN.

A thorough mechanic, 31 years old, 13 years' experience, has had charge of department in Blankord Machine Co., wishes a change with a different class of work. Can handle men to advantage and secure rapid work without antagonizing the men. Best references.

Address, FRANK JONES, 25 Blank St., Blankford, Conn.

VISE HAND.

A machinist with ten years' experience at high grade engine vise work, would like a similar position with a view to eventually taking charge of the department.

Address, GEORGE BROWN, 46 Dash Ave., Dashville, Ohio.

These statements *are not published;* but copied by a typewriter on uniform sized sheets of paper and filed in our REGISTER, typewritten copies being sent to employers needing such assistance. Each application is continued in the register until the desired position is secured, provided the time does not exceed six months.

To employers who are seeking employees in the above trades we will send copies of five applications with names and addresses, for four cents in stamps. If we have no applications on file that answer the inquiry we will advertise for them at our own expense. We give below a few sample applications from our Register, all furnishing good references and apparently from men well qualified in their line of work. Every employer will see the advantage of having such a list as this to select from.

APPRENTICE—19 years old, wants to finish trade.
DRAFTSMAN—21 years old, to work into engineering.
" —College graduate with 2 years shop experience.
" —7 years experience designing machinery.
" —Technical education; high speed engine work.
MECHANICAL ENGINEER: as chief draftsmen or superintendent. Long experience in shop, designer of engines, mining machinery, etc.
" " —16 years shop experience, designer, special tools.
" " —21 years experience, marine and stationary engines, careful at estimating.
" " —14 years experience, machine tools automatic machinery and structural work.
" " —Long experience with engines, boilers, rolling mills, hydraulic work and power transmission.
" " —4 years experience in designing and construction of electrical and general machinery, member of A. S. M. E., long experience on electric cranes and hoisting machinery.
ASSISTANT SUPERINTENDENT OR FOREMAN—18 years experience, pumps, engines, etc.
" " " " 17 years experience, sewing machine and bicycle work.
" " " " 27 years experience, bicycle and sewing machine work.
" " " " 6 years experience in locomotive repair shop; good education, can handle men and get out work economically; age 29.
VISE HAND—8 years experience on good class of work.
" " —20 years experience on general job work.
SALESMAN—A thorough mechanic, 34, would like to travel for some good house in machine or engine line.

WANTED.—Competent man to erect heavy compound engines. Must do some traveling. Preference will be given to one well up in indicator practice. Address, with age, experience, and salary expected.

M. M., Care MACHINERY, 411-413 Pearl St., New York

WANTED.—A bright, energetic young mechanic in every State on subscription work for MACHINERY. This paper is well known everywhere, its representatives are always courteously treated and given every opportunity to carry on their work, consistent with the rules of the shops they are visiting; and this work therefore affords a chance to see life and acquire experience and information among the shops of your State which will undoubtedly be of great value in future. State age and last employment.

Address, MACHINERY, 411-413 Pearl St., New York.

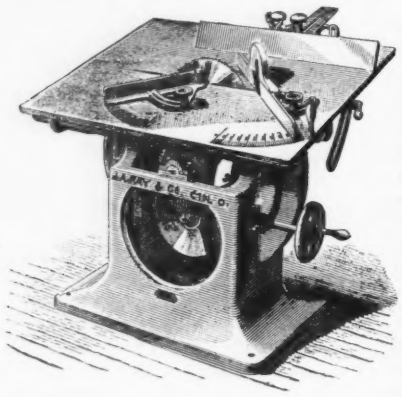
WANTED.—A machine tool builder in New Hampshire is in need of a good pattern-maker. Address,

P. M., Care MACHINERY, 411 Pearl St., New York.

MACHINES FOR PATTERN SHOPS.

DOUBLE REVOLVING CIRCULAR SAWING MACHINE.

For economy of space, accuracy of work and convenience of adjustment, the double revolving circular sawing machine, manufactured by J. A. Fay & Co., Cincinnati, O., is unsurpassed. For ripping and cross-cutting light materials in pattern shops its application is unlimited. It has two steel arbors mounted in a heavy frame which rotates around a central axis, so that one saw can be easily changed for the other. One carries a rip, and the other a cross-cutting saw, both driven by the same belt from a counter-shaft below the machine, or a special counter-shaft and idlers placed upon the floor at the rear.



A worm gear connects with the saw arbor frame, and by turning the hand-wheel, either saw can be adjusted to cut all its size will admit, or less, allowing grooves of varying depths to be made. The table is 44 by 34 inches, and it can be adjusted to any angle up to 45 degrees and instantly returned to a right angle.

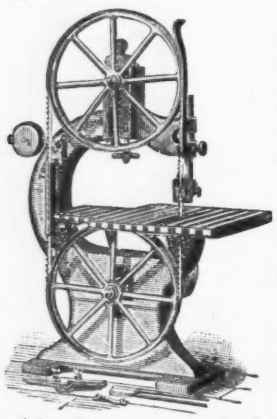
It is made in two sections. The right-hand side is stationary, and used for ripping; the left section is 19 inches wide, and used for cross-cutting. One side runs upon friction rolls, the other being guided upon planed surfaces, retaining it always parallel with the saw.

It can be moved away from the saw to allow of the use of grooving heads in place of the saws. The table when set level is held in position by a curved slotted bar. A graduated scale marks the angle of inclination. The fence has a parallel movement upon the table, and can be set to work different bevels.

There are also two graduated quadrants on the left section of table, each having an adjustable fence for cutting right and left angles. It is equipped with one each 14 inch rip and cross-cutting saw, wrenches, miter fences, counter-shaft for below the floor, etc.

NEW NO. 2 SCROLL SAW.

The new No. 2 scroll saw with patent differential strain, manufactured by the Egan Company, Cincinnati, has many advantages and conveniences which place it far in advance with any machine of the kind yet placed on the market. This company have always excelled in scroll saws, and having made a specialty of them for many years, has over ten thousand of its original No. 2 machine in actual use at the present time. This new machine eclipses their former efforts and is superior to all others in the following points:



The absence of friction on the strainer and the lightness of the cross-head produces no perceptible jar, even when running at the enormous speed of 1,600 revolutions per minute. The machine can be run in top stories of any factory without shaking the building.

The upper part of the strain consists of a differential traversing pulley in connection with a leaf spring, which gives an even tension and does away with all friction and slides.

The adjustable slides below the table are of the best gun metal, have self-oiling globes, and the cross head, which works in same, is of solid forged steel. The changing from inside to outside work is quicker than on any strained or unstrained saw. The operator passes the end of the saw through the table until it strikes a plate, whence it slides into the cross-head. It is impossible for the saw to miss catching and no screw is required to hold it. The machine has a patent combined shifter and brake.

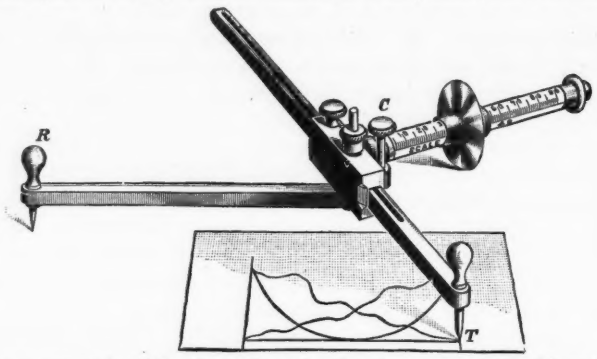
This saw will be found most useful in pattern shops and other places requiring scroll sawing. The machine is well built, it is tested and tried by the makers before shipping, and is warranted by them in every respect.—*Adv.*

THE LIPPINCOTT PLANIMETER.

There is always something interesting in the planimeter, even if not used in our everyday work, and anything new or novel in this line is sure to attract attention. In the instrument shown Mr. Lippincott has introduced several novel features.

The main feature is the glass tube on which the knife-edge roller slides and which contains the scale, printed on a specially prepared paper which is very easily read; a marked contrast to some of the old german silver scales which need an application of the X ray to make the reading clear. The planimeter can be set to read mean effective pressure by merely taking the length of the card between the tracing point and the pin at the hinge, which is pressed down at will, but remains up out of the way at all other times.

When the reading is desired in square inches, the points are set five inches apart for a fifty-cale, six inches for a sixty-scale, etc.; the tubes



contain one scale of the desired graduation to correspond with spring used in indicator. They are made by the Hine & Robertson Co., 75 Cortland street, New York City.—*Adv.*

* * *

BUSINESS.

NO CHARGE IS MADE FOR THE INSERTION OF BONA FIDE ITEMS UNDER THE ABOVE HEAD, FOR FURTHER PARTICULARS, ADDRESS THIS OFFICE.

We have an inquiry for the makers of machines for straightening pipe.

* * *

MANUFACTURERS' NOTES.

JUDGE SWAN, of the United States Court for the Eastern District of Michigan, has recently handed down a very important decision relative to Locomotive Sight Feed Cylinder Lubricators, deciding that the Michigan Lubricator Company's patent is valid, original and does not infringe the Nathan patent. This will cause a reduction in the price of the locomotive lubricators and favorably effect every railroad in the country.

MR. A. D. QUINT, Hartford, Conn., reports the sale of seven of his turret drills in seven days, and considers that business is good with him. In fact, business is generally good in Hartford, probably on account of the activity in the bicycle trade.

THE WATERBURY MACHINE CO., Waterbury, Conn., have obtained an assignment of the "Bolton" patents for continuous wire drawing machinery which have heretofore been imported from England. It will be a great convenience as well as economy for wire manufacturers to be able to procure these machines without sending abroad.

THE increase of business of the Union Manufacturing Co., New Britain, Conn., has made an addition to their plant necessary. This will be of brick, two stories and basement. A large amount of machinery will be added. Their geared scroll chuck which has been recently introduced has grown rapidly in favor and is largely responsible for the addition.

THE RICE & SARGEANT ENGINE CO., Providence, R. I., is sending out a neat announcement of the sale of two cross compound engines of 1,500 HP. each to the West End Street Railway Co., of Boston, Mass. They will have 26 and 50 by 60 inch cylinders, run 80 turns per minute with steam at 150 pounds. Wheels are 24 feet in diameter, weigh 120,000 pounds, and the main bearing is 22 by 38 inches.

WATSON & STILLMAN, 204 East 43d street, New York, have received an order for the building of fifteen draw benches for bicycle tube manufacture, each of them with a stroke of 18 feet.

THE DIAMOND MACHINE CO., of Providence, R. I., has just perfected a new and improved machine for grinding cotton mill spindles from the forging. The machine is a combination of their universal and knife grinders with the necessary attachments for grinding the spindles to the proper taper. The machine gives perfect satisfaction, and although but recently completed orders have been placed by several manufacturers of spindles.

CORNELL UNIVERSITY, of Ithaca, N. Y., is the winner of the prize lathe offered by the Davis & Egan Machine Tool Co., of Cincinnati, O. to the most popular technical or mechanical school in the United States. This is the famous "Silver plated tool room lathe" that attracted so much attention at the World's Fair in Chicago. Cornell had a total of 95,818 votes to her credit, and may well be congratulated upon the acquisition. The Jewish Manual Training School of Cleveland follows with a vote of 85,000 and Cincinnati Technical School comes in third with 65,060 votes. The total number of votes cast amounted to over 1,000,000.

AT the December meeting of the New York Railroad Club the subject of the cause of train detentions was discussed. Mr. C. M. Mendenhall had prepared a very interesting table showing the percentages of the various causes. Fifty-five per cent. of the delays was traceable to the engine, and forty-five per cent. was due to hot journals, etc., on the cars. Mr. Mendenhall's table showed that the greatest number of delays were caused by hot bearings, and that out of every hundred delays caused by undue friction and over-heating of parts on locomotives, 48 were caused by hot driving boxes and 30 were caused by hot crank

Machinists and Steam Engineers
TAUGHT BY MAIL.

Mechanical Drawing Is the most important subject to most men. The demand for mechanics who can make and read drawings is far greater than the supply. Drawing is included in nearly all our courses, the student being required to draw from fifteen to forty plates, and two or more tracings. Our COMPLETE MECHANICAL DRAWING COURSE includes instruction in Arithmetic, Mensuration and the Use of Letters in Algebraic Formulas and Mechanical Drawing. Any person who will follow our instructions can learn to draw by our method. We have made good draughtsmen out of hundreds of young men who, before they enrolled with us, had never had a drawing pen in their hands.

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